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CONTENTS

EDITORIAL:
- Lighting . . . 389
- The Home of the Future . . . 390
- The Chemistry of Incandescence . . . 390
- Electrical Equipment for Docks . . . 391

The Status of Illuminating Engineering, by Dr. Louis Bell . . . 392
Incandescent Lamp Development During the Last Twenty Years, by S. E. Doane . . . 393
The Recent Incandescent Lamp Developments and Their Significance, by Francis W. Willcox . . . 396
Liverpool Electric Railways . . . 402
The Illumination of Niagara Falls . . . 402
BOOK REVIEW . . . 403
Economical House Lighting, by Van Rensselaer Lansingh . . . 406
The Flaming Arc Lamp, by J. H. Hallberg . . . 408
A French Electric Villa . . . 408
Electrical Supplies for the Navy Department . . . 408
Wireless Telegraphy . . . 409
The Effect of Higher-Efficiency Lamps on Station Output and Income . . . 411
The Helion Light, by Walter G. Clark . . . 413
The Sirius Colloid Lamp, by Paul McJunkin . . . 414
The Flaming Arc Lamp, by Thomas Spencer . . . 415
Incandescent Electric Lamp Manufacturers of the United States . . . 419
Photometry at the Bureau of Standards, by Dr. Edward P. Hyde . . . 424
Some Artistic Requirements of Artificial Illumination, by Bassett Jones, Jr. . . . 426
Photometric Units, by Preston S. Millar . . . 428
The Nernst Glower and the Present Status of the Nernst Lamp, by Otto Foell . . . 432
The Mercury Vapor Lamp, by Percy H. Thomas . . . 435
Recent Developments in Metallic Flame Arc Lamps, by G. Brewer Griffin . . . 438
The Moore Light and Illuminating Engineering, by D. McFarlan Moore . . . 440
Recent Developments in Direct-Current Vertical Edgewise Instruments, by H. W. Young . . . 442
REVIEWS OF CURRENT ENGINEERING AND SCIENTIFIC LITERATURE . . . 444
METHODS OF GETTING NEW BUSINESS . . . 448
INDUSTRIAL SECTION:
- The New Lamp Factory of the Brilliant Electric Company . . . 448
- Mexican Light and Power Company . . . 448
- New General Electric Instruments . . . 448
- Some New Jandus Specialties . . . 449
- The New Plant of the Novelty Incandescent Lamp Company, Emporium, Pa. . . . 449
- The Fort Wayne Series Alternating-Current Arc Lamp . . . 450
- Some Tregoning Specialties . . . 451
- General Incandescent Lamp Company, Cleveland, Ohio . . . 451
- The "Linolite" System of Lighting . . . 452
- Candle-Power Curves Secured with Flame Arc Lamps . . . 452
- The X-Ray "Helmet" Reflector . . . 453
- The Just Tungsten Lamp . . . 453
- The Germania Reflector Lamp . . . 453
- Suspension Type Insulator for High-Voltage Transmission Lines . . . 454

CURRENT ELECTRICAL NEWS . . . 455
RECORD OF ELECTRICAL PATENTS . . . 460

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LIGHTING.

Certainly, the use of artificial light, dating as it does from prehistoric times, was one of the most important civilizing agents which man devised. Adopted first merely to lengthen the day and shorten the night, artificial illumination has come to have other and nearly as important uses. Thus, the well-lighted streets of a city are made far safer because of the lighting. In fact, many years ago the value of street-lighting as a means of getting rid of highwaymen was well realized.

The use of artificial light has been developed along with our civilization, and the improvement of methods has been a problem ever under consideration. At times great advances have been made which form marking stones in the history of the art, and at times, this development has lagged, and then again some discovery or invention has carried it rapidly a long way ahead. Thus, the old open wick lamp of the ancients was improved but little until Argand's invention of the burner which bears his name, and the use of this with a chimney. Other marking stones have been the introduction of sperm-oil, afterward to be replaced by petroleum, the invention of illuminating gas, and later the use of electricity in its various forms, which for convenience may include acetylene, this being, in a sense, a secondary use of electrical energy.

Among the electrical appliances there are also stepping-stones marking the progress of the art. Thus, first comes the invention of the arc lamp; next the invention of the incandescent conductor, to be followed by the incandescent non-conductor and the incandescent vapor. Illuminants of all these various types are to-day in use. They now seem to have reached an advanced stage of development, though the progress has not been at all uniform, often the art remaining nearly stationary, and at other times going rapidly forward. At the present time we are in one of these periods of rapid development. In fact, this development has gone on at such a rate that it has become difficult for any one who does not make a special study of the subject to keep pace with it. For this reason, it seemed desirable to bring together records of what has been done in the various sections of the field of electrical illumination.

With this end in view, we present in this issue of the ELECTRICAL REVIEW a group of articles covering the entire field of electrical illumination, each of which has been prepared by some one particularly competent to describe the phase of the subject with which he deals. This issue thus gives a record of what has been accomplished, and shows the stage which has been reached in the development of the various types of lamps.

THE HOME OF THE FUTURE.

Frequently we have ventured upon the prediction that in the home of the future electricity would play a large part; that it would be the main dependence of the housekeeper, and might possibly solve the servant problem which has become so serious in recent years. This idea has been carried out in a number of instances in which very free use of electrical appliances has been made in the home. But none of those which have been described before can compare with that which has been made by Monsieur Gëorgia Knap, of Troyes, France. This home is described in the September issue of the *Architectural Record*. A brief abstract of this description is given on another page of this issue.

By means of various ingenious appliances, much of the housework is done electrically. The gate of the villa, although some distance from the house, is controlled by a motor from the house. By means of a telephone, a searchlight, and a series of mirrors, any one at the house can converse with and examine the person seeking admission. Within the house, not only has M. Knap used those electrical devices which others have brought out, but he has invented a number of ingenious appliances of his own. For example, he adds to his electric oven an automatic indicator which gives warning when any dish has been fully baked. He banishes the waitress from the dining-room replacing her by a small dumb-waiter and an electric railway on the table. The comfort of the guest is taken care of by means of well-arranged electric lamps, by foot-warmers under the table, heaters arranged about the room, and by an automatic ventilating system which introduces fresh, perfumed air when the temperature of the room rises above a certain point. Other rooms of the house are equally well fitted, and, wherever possible, the work of the servants has been reduced to merely directing the operation of electrical devices.

But M. Knap has not been satisfied with his electrical home, and he has drawn up plans for an elaborately equipped house which he believes may be taken as a model of the homes built, say 100 years from now. Not satisfied with controlling the temperature of the house during the cold weather, the designer thinks that it is just as essential to the comfort of the inhabitants to control its temperature during the hot weather, and for this purpose he has designed his house with double walls, separated by a space about two feet wide, through which warm air is circulated during the winter and cool air during the summer. Within this space will also be placed not only the necessary wiring and pipes for supplying the different rooms and affording communication, but also dumb-waiters running to all the rooms. Each room will also be fitted up so that a touch of a button will raise or lower the shades, open or close the shutters or the windows, will flood the room with light from electric lamps, control its temperature, or bring refreshments from the pantry, and the mail and the morning papers as soon as they are delivered. In this way he purposes giving each occupant of a room all the luxury which could be afforded by a whole staff of servants, without its actually being necessary for any one to enter the room. Every room he plans to fit up in the same way, so that no matter where the occupant may be he can command all the services of the house by a slight pressure of the finger. M. Knap's plans may seem rather utopian, yet it may be pointed out that he has not suggested a single application of electricity which could not to-day be easily carried out, and it is more than likely that it will be used in the home in more ways than we now imagine, in addition to those which we are now striving for. Will not each person be provided with a wireless telephone set for communicating with any one else in the house? Will not each room have an electric device for transmitting sight? And M. Knap has entirely overlooked the loft for the electric airship without which no house will be complete.

THE CHEMISTRY OF INCANDESCENCE.

In the present active search for improved forms of illuminants, all efforts seem to be directed toward goals thought to be practically attainable, and but little is said about the ideal illuminant—that which should radiate what some have called "cold light." Various physicists have described the characteristics which such an ideal source of light should have, and although they have not indicated any way in which it might be hoped to reach this goal, they have said that, theoretically, it was not impossible to approach closely to, if not attain, the goal itself. The present efforts are directed toward what seems to be immediately practicable, and are therefore, in a sense, more interesting than the theorists' ideas. Nevertheless, the latter is interesting and important as well, since it keeps in mind the inefficiency of the best of our illuminants, and encourages us not to be satisfied with what we have done, but push still further upward.

The recent meeting of the British Association for the Advancement of Science has furnished a number of topics for discussion. One of these, bearing somewhat upon the question of illumination, was touched upon by Professor A. Smithells, in his presidential address before the chemical section of that society. Dr. Smithells's address dealt largely with flames, and the chemical processes involved in such reactions. Naturally, the greater part of this discussion will have little bearing upon electric illuminants, yet it is a fact that light is produced by incandescence, a state most frequently produced by heat, although in one case the heat is due to a chemical action, and in another to an electrical effect. Any explanation of the way in which a chemically produced heat gives rise to incandescence may therefore be of great service to the electrician who is seeking a better method of producing electric light than by degrading electrical energy, and thus obtaining but a very small fraction of it in the form of light.

One of the interesting points brought out by Dr. Smithells is the gradual passage from a state of phosphorescence to that of ignition. The temperature of ignition has been defined as that at which the initial loss of heat due to conduction, convection, etc., is equal to the heat evolved by the chemical reaction. But he showed that combustion will take place at a lower tem-

perature if the necessary heat be provided, and that the rate of combustion will, of course, vary with the amount of heat supplied from the outside. The phosphorescent state is usually reached before the ignition temperature, and, in fact, the passage through this state is normal, and there is no abrupt change from phosphorescence to combustion.

These are said to be the views now most acceptable to the chemists. Upon the assumption that they are correct, it is interesting to inquire whether thermodynamic laws are not applicable to the phosphorescent condition. If so, phosphorescence must be a very inefficient method of producing light, and it may be questioned whether the high efficiency which has been given for the light-producing organs of phosphorescent insects is correct.

Regarding the actual mechanism of the process of producing luminosity, Professor Smithells says that our knowledge is sadly deficient. He alluded briefly to the theory that in a flame this luminosity might be ascribed to the ions of the metal, as Arrhenius had pointed out the similarity between electrical conduction in gases and in liquids. This might explain the definite spectra given by the elements, yet it does not show how a single body, such as an ion can produce such complicated spectra as those shown by many of the elements. It is interesting to note here that Lenard has shown that a stream of luminous vapor such as is produced by sodium in a Bunsen lamp is deflected in an electric field in such a way as to indicate that the vapor is positively charged. But Lenard does not think that this is the uniform condition of the vapor. He believes that when part of the vapor is charged, the principal series of lines in the spectro-sodium is due to the electrically neutral atoms, the other groups being due to atoms which have lost one or more electrons. Lenard has extended his studies to the flame of the electric arc, and has shown that here there are three different kinds of radiation from the three structural regions of the arc, and the spectra of these differ. These ideas, in addition to being interesting from the point of view of the student of methods of producing light, are also of interest from the bearing which they have upon the use of the spectroscope for chemical analysis. Some time ago we called attention to a paper published by Dr. John Trowbridge, in which he pointed out that the spectrum of an element due to an electrical discharge was influenced by the environment; hence, it was suggested the spectrum of an element may not necessarily be absolutely fixed. The same thought is suggested by this study of Lenard's.

Another rather interesting phase of Professor Smithells's address, though not in any way connected with electrical engineering, is his reference to the introduction of mathematics into chemistry. After justly extolling the merits of the chemical manipulator and his wonderful skill, he said: "There is never more cause for anxiety than when we see a mathematical theory awaiting the delivery of the confirmatory facts." The idea that the introduction of the use of what may be called the most perfect of sciences, mathematics, into chemistry is dangerous, particularly when the mathematical predictions are verified by facts, seems strange to those whose sciences, or their applications, have been built up so largely by mathematical reasoning.

ELECTRICAL EQUIPMENT FOR DOCKS.

At a recent conference of the Institution of Civil Engineers, of Great Britain, W. W. Squires compared the relative advantages of electrical and hydraulic appliances for the work of docks. Some of the points which he made seem worth repeating. For cranes and elevators where the loads normally approximate the maximum, the advantage appears to be about evenly balanced between the two systems. But the first cost of the hydraulic is said to be a little lower. On the other hand, for variable loads, the electric system should be much the more efficient. For other mechanical apparatus for handling materials, electricity seems to be much more suitable, such, for example, as conveying belts and traveling hoists. For driving rotating machinery, it is, of course, much the better. On the other hand, the hydraulic system has an advantage as a protection against fire, though this is a duty for which, fortunately, it is seldom necessary to call. Against this advantage of the hydraulic system may be placed the greater ease of running the electric wires as compared with water pipes, and the freedom of the former from damage by freezing and the facility with which portable apparatus, such, for example, as fire pumps, may be operated. For widely distributing power from the point of generation, the electrical system is much the cheaper. On the whole, the conclusion seems to be that the electrical system is the most advantageous, and because of the varied uses which may be made of the electric energy, the electric generating stations can be operated under more satisfactory conditions than can the hydraulic.

One point which Mr. Squires makes in favor of the hydraulic system is the ease with which hydraulic power may be stored. The electric storage battery, he says, can not compare with the hydraulic accumulator as regards cost, reliability, and ease of maintenance. On the other hand, the efficiency of the hydraulic accumulator can only be high if the loads handled or the work done be approximately constant, as to produce a certain motion or to lift an article a certain distance requires a definite movement of the hydraulic piston, and this calls for a definite quantity of water, irrespective of what the load handled may be. Since this water must all come from an accumulator which is maintained at a practically uniform pressure, the energy used up during any motion of the hydraulic device operating from the accumulator must be nearly constant and practically independent of the load. The electrical system, on the other hand, draws energy approximately proportional to the work done.

Mr. Squires, in concluding his short summary, points out the increasing tendency toward the use of electrical appliances for dock work, and says the advantage of the system on such is to indicate a still further development in this direction, with increased experience.

The Status of Illuminating Engineering.

By Dr. Louis Bell.

THE rise of illumination to the rank of a well-defined art is a thing of very recent years. It is in fact linked with the later development of electric lighting in a way that in part at least accounts for the popular error of considering illuminating engineering as a branch of electrical engineering. The real fact is that electrical energy being a somewhat costly source of light, although a very convenient and important one, the need of economy in its use has forced the study of efficient methods of utilization. Incandescent lamps, even the best of them, are of low luminous efficiency and the main chance for economy lies in using them to the best advantage. I have said that it is an error to consider illuminating engineering as distinctively electrical. True, one who undertakes it must know well the applications of electricity to lighting, but he must, even if actually in the service of an electric lighting company, also know well the technique of gas lighting, and the special characteristics in fact of all illuminants. The art of proper illumination is far broader than the commercial application of any particular kind of light.

Some one has defined an engineer as a fellow who can do for fifty cents what any fool can do for a dollar, and to specialize a bit, one can say that an illuminating engineer is a chap who can do with one candle-power what any fool can do with two. The particular kind of ability which can accomplish this is now, and is likely to remain, rather scarce. Neither the average solicitor nor the average electrician can pick it up at short notice, if at all, for it depends on a knowledge of many things not found in the training of either. Illuminating engineering in fact is as much a branch of physics or of architecture, almost of physiology or of æsthetics, as it is of electrical engineering. A student of architecture indeed could specialize in it quite as effectively as a student of electricity, and each would find the major part of his professional training inapplicable. It is not at all sufficient today that a solicitor should be able to speak glibly of the merits of "our a, b, c, special lamp with standard Goo-goo reflector," or solemnly to read off the candle-power figures in his hand-book and assure the customer that the light will be the most brilliant on the block. There has been plenty of that sort of thing in the past, and it is pretty well played out already. It is time that the professional schools of electrical engineering, of architecture, and of general science, gave some opportunities for young men to acquire some sound knowledge of the principles that underlie the proper use of illuminants both natural and artificial. What little instruction in lighting is now given is mostly from the standpoint of mere technical methods without due regard to the results as the all-important thing. Even photometry, of special importance in all illuminative work, is generally taught in a fashion entirely perfunctory without the least thought of anything beyond getting the candle-power distribution of a few familiar sources.

Now, in fact, the technique of illumination covers a very wide range of scientific matters. The modern city turns night into day and human activities are so stretched into the hours of darkness that provision must constantly be made for night work, even in the finer industries. Under such circumstances the absolute need of good lighting becomes obvious, even from the standpoint of mere commercial expediency. In factory or workshop the quality and quantity of the product is very acutely affected by the quality of the artificial lighting. If this relation existed only for a half hour or so at the close of a winter day it would be worth considering, but actually it may involve practically continuous night shifts for long periods at a time. Every year sees many industries passing into the condition where they work not at an even pace, but by tremendous spurts alternating with periods of diminished output. In a press of work success or failure may turn on illumination for the night shifts, and the dread of night work felt by many managers comes as much from experience with bad lighting as from any other one factor. The long and short of the matter is that if, as is the case in modern life, there is a growing tendency to turn night into day, illumination must be studied almost as a fine art. The necessity is, from a humanitarian standpoint, to be regretted, but it must be met, and though the starting point of illuminating engineering was originally economy in utilization, it has grown by reason of the conditions just mentioned into the more serious function of planning artificial lighting to meet almost every imaginable kind of special requirement.

If the engineer has to plan one day the economical illumination of a private house, the next it may be a factory, a machine shop, a night school, a theatre or a church, each one demanding treatment in a radically different way. In one case economy may be the keynote of success, in another it may become the certain guarantee of failure. Here the physiological side of the matter may be all-important, and there it must for the time being be almost completely neglected. The man who attempts to follow up the requirements of modern lighting by any cut-and-dried system of standard appliances, or by any commercially convenient specifications, is certain to come to grief in rather short order, for no task involves more adroit and flexible specialization or more instinctive knowledge of methods and results.

The practical side of the situation is this, that the necessity for a new kind of professional work has rather suddenly arisen, before the work itself has assumed entirely definite shape and before there is any adequate provision for training up men to do it. The same sort of necessity has arisen again and again, as in the beginning of electrical development, the start of the automobile industry and the awakening of modern electrochemistry. In the present instance the affair would take care of itself in due season were it not for the suddenness of the demand and the entirely mistaken idea that any electrician with common sense can pick up in short order the technique of illumination. It is quite inevitable that the result should be a period of very ragged and unsatisfactory results out of which better things will struggle. The moment one passes from the crudest commonplaces of illumination he plunges into a maze of uncertainties from which the art can be extricated only at the expense of an amount of study and effort that is almost inconceivable to one who looks upon one light as very like another and upon all fixtures as good provided they are fashionable. The very fundamental data for computing a required illumination are still vague and imperfectly comprehended, and the whole scientific side of the subject requires persistent investigation. More than this, the art as apart from the science has great practical importance, and

a man who is entirely competent to plan the illumination of a department store may fail miserably on a church or a library from sheer incapacity to realize the æsthetic necessities of the case. People are only beginning to appreciate this phase of illumination. A few far-seeing spirits, chief among them the late Mr. Stieringer, grasped it instinctively. Nothing finer than the illumination of the Court of Honor at Chicago has been seen since, unless it be the work of the same master at Buffalo.

A deal of hard grinding will be necessary before illuminating engineering as a profession is fairly established. It probably never will take rank as a big profession, but rather as a most useful and highly specialized branch, like sanitary engineering. Preparation for expert work in illumination must include three lines of study of co-ordinate importance. It must be based on a thorough technical knowledge of the applications and economics of illuminants as such; next it must include a considerable understanding of physical and physiological optics as related to illumination, and finally it should cover something of the æsthetic side of architecture.

The buildings of a modern city should be planned for night effect as well as for day effect, since the darkness is year by year being abolished, and this applies to interiors and exteriors alike. In fact, for the greatest opportunities of illuminating engineering, architecture is a better starting point than any branch of engineering proper. Unhappily architecture and engineering are too widely separated in technical schools to enable a student to work in both lines, and the courses in architecture are as weak in physics as those in engineering are in æsthetics. As a temporary expedient at least, it would seem advisable for technical schools to start on the study of illumination by arranging courses open to students in several departments on much broader lines than the customary perfunctory study of electric lighting, and preferably not tied down to the electrical department at all. Illuminating engineering is far nearer to applied optics then to applied electricity. With available courses of instruction once open, the relation of illumination to professional study will begin to take form, but for the present it is very indeterminate. For the next few years the working ranks of illuminating engineers will be filled by men largely self-trained and approaching the subject from various sides. These will be successful about in proportion to their natural resourcefulness and the scope of their general training. The sooner, however, some definite attempt to give really helpful instruction to students is made the less time will be wasted in ill-judged and ineffective labor. The only substitute for the present is the scattered literature of the subject, already somewhat extensive, but still full of the crudities and misapprehensions that are inseparable from the opening of a new field in applied science. It is encouraging that blunders are not more numerous and that the work now being done bears evidence of enthusiasm and faithful effort.

Incandescent Lamp Development During the Last Twenty Years.

By S. E. Doane.

IN writing a résumé of the most interesting features of the incandescent lamp development, during the last twenty years, I have necessarily called attention to those things which have particularly appealed to me. I hope that my readers will find that this summary is of interest to them.

The Thomson-Houston Electric Company, where I was introduced to the lamp business in 1886, was manufacturing about three hundred lamps a day, a very small output in comparison with the output of even the smallest factory of today. In fact, it is extremely difficult for any factory to operate profitably which does not manufacture ten thousand lamps a day.

The filaments were made of cotton thread. All of the other companies, with probably one or two exceptions, were using some sort of thread for their filaments. The deposition of graphite on the filament was not at all understood, in fact, the Edison company claimed at that time that its untreated filaments gave better electrical results than the cotton filaments. It might not be generally appreciated that even at this date experiments are being made on materials other than carbon, and that these researches have been continued with considerable persistence, on the part of some, up to the present day.

MR. S. E. DOANE, CHIEF ENGINEER, NATIONAL ELECTRIC LAMP ASSOCIATION.

The history of the Thomson-Houston Company in this respect, was not exceptional. I know now that the Sawyer-Man, Brush, Westinghouse, Shaefer and Edison companies were vigorously experimenting. Concerning the latter, it might be truer to say that Mr. Edison was experimenting vigorously in his laboratory. He was, of course, the principal figure in the company, and, so far as that goes, in the incandescent lamp business at that time. Things continued in this condition, the companies experimenting with every effort at their command. To attempt to give the dates at which the various changes were made, and details of these changes in the different processes in these factories, would be impossible in an article of this length. It is sufficient to say that the lamp companies were using cotton, silk and bamboo for filaments, and that at about this date, the general change to bamboo was begun. The Thomson-Houston Electric Company abandoned its cotton filaments and changed to bamboo, and all of the other companies changed likewise, with one or two exceptions. Later developments showed that they had changed advisedly, although it is my impression that some of the companies continued to use silk until the change to cellulose filament was brought about.

The courts had decided that Mr. Edison was the first to make the modern incandescent lamp. There is probably no question that he made the first bamboo

filament. While, for a long time it was believed that the Sawyer-Man Company was the first to make a graphitic deposition on a carbon filament, and while there may be come doubt as to this, it is nevertheless true that the Sawyer-Man Company was the first company, or one of the very first companies to adopt this filament. Its lead was rapidly followed in this particular by the other lamp companies with the single exception of the Edison company, which continued to use its untreated carbon filaments. There was a rapid development in processes and methods, but no single change of any great magnitude was made until the adoption of the cellulose filament and the present type of lamp stem and seal.

The next change of any great importance in the lamp business (the adoption of the cellulose filament) was presaged when E. W. Rice, then superintendent of the Thomson-Houston Electric Company, brought from England and the Continent four chemists who had had experience in lamp work, to develop the cellulose filament.

Nothing resulted immediately from their effects, the filaments they made proving unsatisfactory on test.

The Buckeye Electric Company produced a lamp with a cellulose filament in 1891, but the quality of this latter lamp proved to be no more satisfactory than the earlier efforts of the Thomson-Houston Company. The Buckeye Electric Company, however, continued to use it.

The consolidation of the Edison Electric Light Company and the Edison Electric Machine Company to make the Edison General Electric Company in 1892, was followed by the consolidation of the Edison General Electric Company and the Thomson-Houston Company to form the General Electric Company. For some time after this consolidation, the lamp departments of the two constituent companies operated separately, interchanging data and experiences, but it was not until 1893, when panic conditions became acute, that the Thomson-Houston lamp department was consolidated with that of the Edison and transferred to Harrison. The development of the cellulose filament was again taken up and in the fall of 1893 this filament was put upon the market. The quality of this lamp, while not equal to that of the modern lamp, was, nevertheless considerably better than that of the lamps which had preceded it. The panic of 1893 slowed up the rate of development, the companies being pressed to keep their heads above water. To make it more difficult for these companies, the General Electric Company at about this time (the fall of 1893) secured its patent decision on appeal against the Sawyer-Man Company, and immediately thereafter shut down nearly all of the lamp companies, and so harassed those remaining in business, that lamp development was again at a standstill, excepting in the Edison factory, where we were sparing no effort to raise the quality to the highest possible standard. The lamp history at this time, because of the conditions above cited, for a time becomes the history of the development of the Edison company. A great many minor changes of importance followed the combining of the activities of these two companies.

Up to this time the Thomson-Houston Company in Lynn had maintained, so far as my information goes, the only really complete life-testing facilities for testing the lives of its lamps, and thereby interpreting its experiments and watching their quality. Mr. Edison had maintained at his laboratory such facilities, but after the consolidation, an experiment and life test department was developed at Harrison, and, much enlarged and improved, exists there to-day.

During this period, the untreated carbon lamp was abandoned and the treated cellulose filament was introduced. The form of lamp seal was changed, molded bulbs were adopted instead of the old hand-blown bulbs, and other minor changes were made resulting directly from the combination of the experiences of the two companies. The Edison factory was greatly changed in its equipment, and as before stated, the changes resulted in a marked improvement in the quality of the lamps and reduction in their cost of manufacture.

The adoption of the cellulose filament brought a change in the appearance of the lamp. Our tests had shown that the greatest length of filament which could be gotten into a lamp was greatly to be desired, so that when the length of the filament was no longer limited by the length of the bamboo splint, the lamp engineer immediately made as long a filament as the size of the bulb and the then improved, but still comparatively crude, methods of lamp manufacture permitted. The first filament of increased length was an unanchored filament with a single coil. The logical development of this was the modern oval-shaped filament, which quickly followed the placing on the market of the single-coil filament.

Inasmuch as the Edison company was now supplying practically all the lamps in the United States, this had the effect of standardizing the oval anchored filament and the molded bulb. The first molded bulb adopted by the Edison company was of the Thomson-Houston shape, but this was soon abandoned for the present straight-side shape.

In 1895, word came to this country of the use of the chemical exhaust by Arturo Malignani, an Italian, who was exhausting lamps by vaporizing phosphorus in the interior of the lamp bulbs, after they had been almost completely exhausted by a mechanical pump.

I might say that while several mechanically exhausted lamps had been placed upon the market, the lamps exhausted by this process were the first lamps of high quality which had been commercially so produced.

The value of this method of mechanical exhaust lay not so much in the high quality of lamps, as in the large percentage of perfectly exhausted lamps. Good lamps had been produced by the old exhausting methods, and while a good operator by the old methods would produce a large percentage of perfectly exhausted lamps, the method itself demanded so much of the men that it was difficult to procure good operators.

The chemical method of exhaustion enabled us to exhaust lamps at a bench. This statement means a good deal more than is evident at the first glance. Some of the companies had employed women in their pump room, but with indifferent success, as women of strong physique were necessary on account of the physical requirements of the processes. The effect of this change was to greatly improve the average quality of the product.

Lamp companies, some of which had not been closed down by the patent suits, some of which had started anew and some of which had newly entered the field, gradually obtaining a footing in the lamp field, so that in 1896 and 1897 the lamp business again resumed its condition of competitive activity.

There were no further striking changes in method, apparatus, organization or personnel until in 1901, when a movement was started among the lamp manufacturers, other than Edison, to combine certain of their interests into the most remarkable technical organization in the history of the industry, or possibly in the history of many, if not all, industries.

I have passed quickly over the developments up to this time with the expectation that the reader would be sufficiently fa-

miliar with the situation as it existed to supply the details which space forbids. I now reach a more recent period of development, however, with which, presumably, the general reader is not familiar.

In 1901, the Sunbeam Incandescent Lamp Company, the Fostoria Incandescent Lamp Company, the Columbia Incandescent Company and the Bryan-Marsh Company awakened to the necessity of maintaining a more expensive laboratory and engineering department than it would be possible for any one of them to support in order to do work which no one of them could afford to do alone, and which every lamp company must have done for it in order to make it successful.

Without covering in detail the successive phases of its development, it is sufficient to say that there existed previous to the development of the tantalum and tungsten lamps in Germany, an organization known as the National Electric Lamp Association, and before dealing with these lamps, a word of explanation is necessary as to this organization.

This organization, consisting at first of four companies, to-day consists of sixteen companies engaged in the manufacture of incandescent lamps, who have pooled their engineering and development activities. Their combined factory output to-day is in excess of 30,000,000 lamps yearly, in which respect, it is just about equal to the General Electric Company, the other largest lamp producer in the United States. The organization consists of a president, vice-president, treasurer and secretary, each one of whom is selected from a different lamp company. Under their direction is operated the engineering department of the association, which is to-day expending about one-quarter of a cent per lamp in its work. This is not an inconsiderable item in the cost of manufacture.

The work of the engineering department of the National Electric Lamp Association has thus far been expressed along the five following lines:

Improvement of lamp quality.

Experimental and development work.

Advisory technical supervision of factories.

Production of new lamp literature, specifications, etc.

Giving out technical data having commercial value.

This association does not, in any way, attempt to control the prices of incandescent electric lamps, nor does it exercise any control over its members. Each member is free to take any position on any matter, but the members have voluntarily agreed, for the most obvious reasons, to abide by the decisions of their committees relative to those features of lamp making, which necessarily must be alike for all companies. To illustrate this with the most simple of illustrations, I would say that the association, by agreeing to the suggestions of its engineering department in standardizing the length and the thread of its Edison bases, has avoided much annoying trouble to the consumer in the way of loose bases and the production of bases which would not fit existing sockets. The base manufacturers simultaneously took up the same question with lamp manufacturers not in the association, by which action an agreement was reached which affected every lamp produced in the United States, which was based with the Edison base and gave the insurance companies a definite standard to which they could require the socket manufacturers to conform.

The association has established, through its engineering department, a testing organization for insuring the quality of its chemicals and supplies. Once a month a representative of the engineering department visits each factory of the members of the association and selects at random a number of lamps from the run of the day for life test. These lamps are carefully tested at the engineering department and results plotted and calculated, so that a definite percentage figure is obtained, by which the quality of the lamps produced by these factories can be compared. By agreement among the members, a pooling scheme is maintained on this quality question, by which the lamps, which are high in quality, enable their manufacturers to draw money from the pool, whereas, those which are lower in quality than the average, contribute to the pool. These factories can obtain assistance from the engineering department at any time, and, as the engineering department has access to all factories, it is possible to obtain the experience of all companies.

The engineering department also operates a development laboratory and an experimental department. The American manufacture of the tantalum lamp was developed in this manner, under the supervision of two of the association engineers, who were sent to Germany to study this lamp at the factory of its inventors. This will be taken up in more detail later on in this article.

The energy of the engineering department, along publication lines, has been almost wholly expressed in the data book, furnished the association members, and in the series of bulletins with which the readers of this article are probably already acquainted.

The average results of the tests in the engineering department form the basis for all the figures given out by any association members. It will be noted that this plan in no way limits the individuality of an organization, nor does it limit the technical progress of a company. In fact it encourages the most rapid progress and broadest possible development. I might mention, not as a technical development, but wholly as an instance of the broad spirit of cooperation which has developed among the lamp makers, that the Cooperative Electrical Development Association originated with the association known as the Licensed Manufacturers of Incandescent Lamps. The Cooperative Electrical Development Association quickly outgrew the lamp industry. This association, which gave the licensed manufacturers of incandescent lamps their start, includes all the companies represented in the National Electric Lamp Association, as well as practically all the other lamp manufacturers in the United States. Every one knows the vast amount of good the Cooperative Electrical Development Association has accomplished.

The lighting companies of the country, which appreciating all these things and which in the past pinned their faith to the struggling companies, deserve every possible thing that can be said in praise of such support. Adversity and struggle have bound the consuming companies and the manufacturing companies of the association in the closest kind of community of interest, fellowship and good will, and as I said before, this absolutely unique development of the situation has been one of the most striking technical developments of the art. The whole industry has profited by the technical rivalry and development, so that aside from the National Electric Lamp Association and the other two principal interests in the industry, *i. e.*, the General Electric Company and the Westinghouse Company, the smaller lamp companies, which have no connection with any one of the three interests, have improved their quality and have made striking advances in lamp quality, as a direct consequence of the general training of lamp makers, through the active competitive energy of the three larger interests, as well as, of course, by activity on their own part.

So much for the National Electric

Lamp Association. The rapid improvement in general lamp quality, following the organization of this association, has been paralleled by most remarkable foreign progress, which has produced the tantalum and tungsten lamps.

In order to explain the tantalum and tungsten situation, I have dealt with the National Electric Lamp Association first. Fortunately, the association was formed at a time antedating the commercial development of these lamps. The full development of the association, to the extent I explained above, had not been reached at the time the association was formed, and a portion of the development of the association has been effected to meet the new conditions which these two lamps have brought forth.

The National Electric Lamp Association, by acting as a unit, secured full right to the tantalum lamp, in common with the General Electric Company. The value of this fact, to lamp users, can not be overstated. There exists to-day the keenest kind of technical competition in the quality of the tantalum lamp, as a result of the fact that the association could act as a unit in the procuring of these rights to produce this lamp.

The tungsten situation is somewhat similar, excepting that the association, there having been several simultaneous developments of this tungsten lamp abroad, has been able to act more independently, so that the quality competition on the tungsten lamp will be even keener than is the competition to-day with the tantalum. Time will more thoroughly show just what this means.

There has been so much technical description of these two lamps, their process of manufacture, their behavior, etc., that there is no need of my saying anything in this connection to add to the length of an article already long enough.

The reader will notice, that in my description of the happenings of the last few years, I have confined myself entirely to the National Electric Lamp Association. There has been no striking development in the processes of manufacturing the carbon incandescent lamp, with the single exception of the production of the Gem metallized filament, which the General Electric Company was the first to put upon the market, but which is now also made by the various National Association members in their different factories, as licensees of the General Electric Company. Had not the tantalum and the tungsten lamp been invented, more would have been said, and a freer development of the Gem metallized lamp would have taken place. It is one of the curiosities of the whole lamp situation that so great an advance, the greatest which had been made in many years, should have been so quickly superseded by even greater advancements.

This lamp has also been so fully covered by the technical press, that further reference to it here would unnecessarily consume the reader's time.

It is impossible, of course, to predict what the future will bring forth. Tungsten lamps on our tests are being operated at one watt per mean horizontal candle, and, while the first lamps the association is putting on the market are rated at one-and-one-quarter and one-and-one-third watts per candle, the situation is not sufficiently developed to predict at all as to what the future will bring forth, relative to this lamp.

There exist to-day, the National Electric Lamp Association, the General Electric Company and the Westinghouse Company, which are simultaneously and separately developing this lamp, presumably by different processes. There are also other smaller lamp interests, which will be obliged, in self-defense, to make some arrangement to meet the existing conditions. It is difficult to believe that they can afford the enormous expense necessary to this development, but as companies of this type have lived and made vigorous progress, such, for illustration, as those composing the National Electric Lamp Association, it is reasonable to believe that through association membership, or otherwise, the condition will be met, and that all companies now in the lamp business will in a few years be found upon the new high plane of quality set by the tungsten filament.

I have necessarily left unsaid much I could have said. The osmium lamp can not have been said to have really reached this country at all, before the tungsten lamp superseded it. It apparently was hardly a commercial development for us. The zircon, Helion and other lamps are in the air.

It is sufficient perhaps to say that the end is clearly not in sight, and that an era is opening for incandescent electric lighting which will be more remarkable than any which has passed, and which will be quite as remarkable as that of any of the other branches of electrical development.

The Recent Incandescent Lamp Developments and Their Significance.

By Francis W. Willcox.

THERE is perhaps no subject of greater interest to mankind than the artificial production of light—no branch of science or engineering that has had a more profound effect upon man's mode of life than lighting and illumination. To realize this we have only to consider what would be the effect on modern life if we had to give up all modern illuminants and revert to the torch, the rushlight and the tallow dip of our forefathers.

The modern science of supplying light has added four to six hours to the average day, and thereby lengthened the allotted span of life by at least thirty to fifty per cent, for light is life and darkness means sleep or death.

Now, as Dr. C. P. Steinmetz has said, in spite of all that has been accomplished, the production of light is the least creditable of all achievements of modern science or engineering, because of the extreme inefficiency of such production. Improvements in lamps and methods of lighting possess therefore most extraordinary interest and value, for the opportunity is great and the rewards and benefits greater still.

All are more or less familiar with the course of development of the incandescent lamp, of the early platinum lamps of Edison, and the carbon filament lamp which, finished invention that it was, has dominated the field of electric lighting for the past twenty years. In this period nothing was added to or taken away from the lamp, but the methods of production were cheapened and a steady improvement in quality was made.

In the past year there has been a remarkable awakening, with such radical improvements as to immeasurably promote the supremacy of the incandescent lamp. The Whitney discovery at the Gen-

eral Electric laboratory of the so-called metallizing or graphitizing of the carbon filament by treating in the electrical furnace, has given a 2.5-watts-per-candle lamp equal in life results to a 3.1-watts-per-candle carbon filament lamp.

In other improvements the art appears to have reverted to the lines of the early lamp developments, *i. e.*, to metallic filaments, and we have the osmium, tantalum and tungsten filament lamps giving efficiencies from two to one watts per candle.

It is just twenty-seven years ago since Edison gave his first public exhibition of incandescent lighting at Menlo Park. During this twenty-seven years the lamp has had a remarkable growth.

The incandescent lamp appears to be a simple thing, but in reality it is very complicated, involving in its construction the consideration of many abstruse chemical, electrical and engineering problems. The most important part of a lamp is the filament, the light-giving portion or burner, which, as is well known, is composed, in the present lamp, of carbon.

Carbon is not the only substance which can be used for the filaments of incandescent lamps. The number of materials, however, is very small, for two reasons: first, the material must be capable of withstanding a very high temperature, and secondly, it must be a conductor of electricity. This excludes most materials except carbon and a few metals. Carbon is a very satisfactory material for filaments because it makes a conductor of very high resistance. If we take the resistance of silver as one, the resistance of aluminum will be two; iron, six; lead, twelve; German silver, fourteen; graphite carbon, 2,600.

The length of a carbon filament is therefore comparatively short, being only ten inches as compared with a length of two feet for a metal filament like tantalum. This and other mechanical features, and its low cost, give the carbon filament many advantages which it is desirable to retain by developing to the utmost its possibilities for efficiency.

The carbon filament, while generally operated at efficiencies of three to three and one-half watts per candle, can be forced to burn for a short time under increased pressure at five or six times this efficiency, *i. e.*, at about one-half watt per candle. The problem of improving the efficiency is therefore to improve the carbon; that is, to make the carbon more refractory, more durable, of a higher vapor-tension point, so that it can be operated at much higher temperature without rapid deterioration. That something is possible along this line is shown by the development of the metallized or GEM filament, which gives sufficient increase of refractoriness to operate at a temperature some 200 degrees centigrade higher than

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is possible for the ordinary carbon filament with the same life performance.

The metallized filament is produced by subjecting the ordinary carbon filament to the temperature of the boiling carbon in an electrical furnace, whereby its characteristics are materially changed. In the metallizing process the raw untreated filament is first subjected to the metallizing process in the electrical furnace and then removed and treated with the ordinary

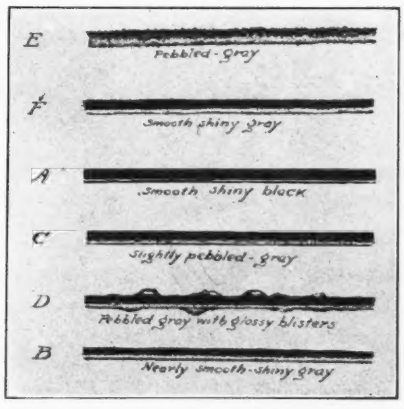


FIG. 1.—MAGNIFIED VIEWS OF GEM FILAMENT UNDER DIFFERENT STAGES OF METALLIZING PROCESS.

"A" Base carbon not metallized.
"B" Base carbon metallized.
"C" Graphite shell not metallized.
"D" Graphite shell metallized on a base not previously metallized.
"E" Graphite shell metallized on a base previously metallized.

hydrocarbon treatment. After treatment the filament is again metallized so that each filament is subjected to two metallizings, before and after the ordinary hydrocarbon treatment. The accompanying illustration (Fig. 1) shows the superficial appearance of the different states of the carbon filament before and after metallizing.

The intense temperature of the metallizing process changes the composition of the carbon filament by removal of the ash residue or content and by the volatilization of the hydrocarbon contained in the filament.

Referring to Fig. 1, the following account, by J. T. Marshall, who has developed the metallizing process, will give a clear idea of the various effects:

When the base or untreated carbon (see A, Fig. 1) is metallized, its weight is reduced about eight per cent, due to the volatilization of the hydrocarbon and ash residue, which are not removed at the usual carbonizing temperature. After metallizing, the ash residue of the base carbon (see B, Fig. 1) is usually below one-twentieth of one per cent. Its specific electrical resistance at seventy degrees Fahrenheit is not greatly reduced. The surface of this filament (see B, Fig. 1) is somewhat roughened and changed from a black lustre to a grayish or slightly metallic lustre. The life of the filament in this condition is not improved at a given efficiency. The usual blackening of the bulb is much reduced.

In C, Fig 1, is shown the graphite shell or coating of ordinary carbon not metallized. When metallizing is applied to this graphite shell its electrical resistance at seventy degrees Fahrenheit is very much reduced. In practice metallizing of this shell is always applied with the base carbon inside and the effects produced are quite different, depending on whether the base has been metallized or not previous to the deposition of the graphite shell by treating, the ash in the base carbon apparently playing an important rôle.

In D, Fig. 1, is illustrated a graphite shell metallized on the base carbon not previously metallized. When metallizing is so applied the specific electrical resistance of the graphite shell at seventy degrees Fahrenheit may be reduced as low as fifteen per cent of its initial specific resistance. Its surface is changed from a smooth gray lustre to a badly blistered black lustre, some of the blisters being perhaps several times the initial diameter of the filament. Its life in the lamp, at a given efficiency, is somewhat longer than that of the unmetallized treated filament at the same efficiency, and the usual blackening of the bulb is reduced.

In E, Fig. 1, is shown a graphite shell

metallized on the base carbon which has been previously metallized. When metallizing is so applied the specific electrical resistance on the graphite shell at seventy degrees Fahrenheit may be reduced as low as twenty-five per cent of its initial specific resistance. Its surface is considerably roughened and pebbled. The filament, when made into a lamp at a given efficiency, will give a life three and one-half times as long as that of the ordinary carbon filament of the same efficiency, or it may be burned at twenty-five per cent higher candle-power with the expenditure of the same energy, and it will give the same life as the ordinary metallized filament, and the blackening of the bulb will be far less. The greater reduction of resistance of the shell of the unmetallized base (as compared with the metallized base) is probably due to the greater amount of ash in the unmetallized base. Manufacturers of artificial graphite have found that the graphitizing process is materially assisted by a mixture of certain impurities with the carbon which is to be graphitized.

Changes of temperature produce changes in electrical resistance of all carbon filaments, but these changes are of different magnitudes for the different kinds of filaments.

Calling specific resistance of copper "unity," the specific resistances of various forms of carbon just described, both at atmospheric temperature and at 3.1 watts per candle-power, are given in the accompanying table.

The practical effect of this metallizing therefore is to give us a filament which is capable of lasting three and one-half times the length of life, at the same efficiency, as the ordinary carbon-filament lamp. Or for the same life it enables us to operate the filament at an efficiency twenty per cent higher, that is 2.5 watts per candle as compared with the ordinary carbon filament at 3.1 watts per candle. That this is a most notable improvement in results is evidenced by the curve showing improvement in lamp quality (Fig. 2), where it is seen that we have in one step made an advance equal to that of the last twenty years' development.

The metallized filament is now produced in a number of sizes of lamps, from 250 watts down as low as fifty watts. It has been chiefly employed in the higher candle-power sizes, forming a line of what are known as "incandescent units," which are lighting units of excellent efficiency obtained by a combination of metallized-filament lamps with suitable Holophane reflectors.

The fifty-watt metallized-filament lamp gives a mean horizontal candle-power of twenty, and this is the standard now being adopted by central station companies in place of the former sixteen-candle-power ordinary carbon lamp, thus giving the consumer twenty-five per cent more light with the same consumption of energy.

Production of still lower wattages in these metallized filaments will be undertaken in the near future. A filament of certain size and thickness is necessary to secure the full effects of the metallizing process. We can not therefore expect as much improvement on low-candle-power lamps below sixteen as on the higher sizes.

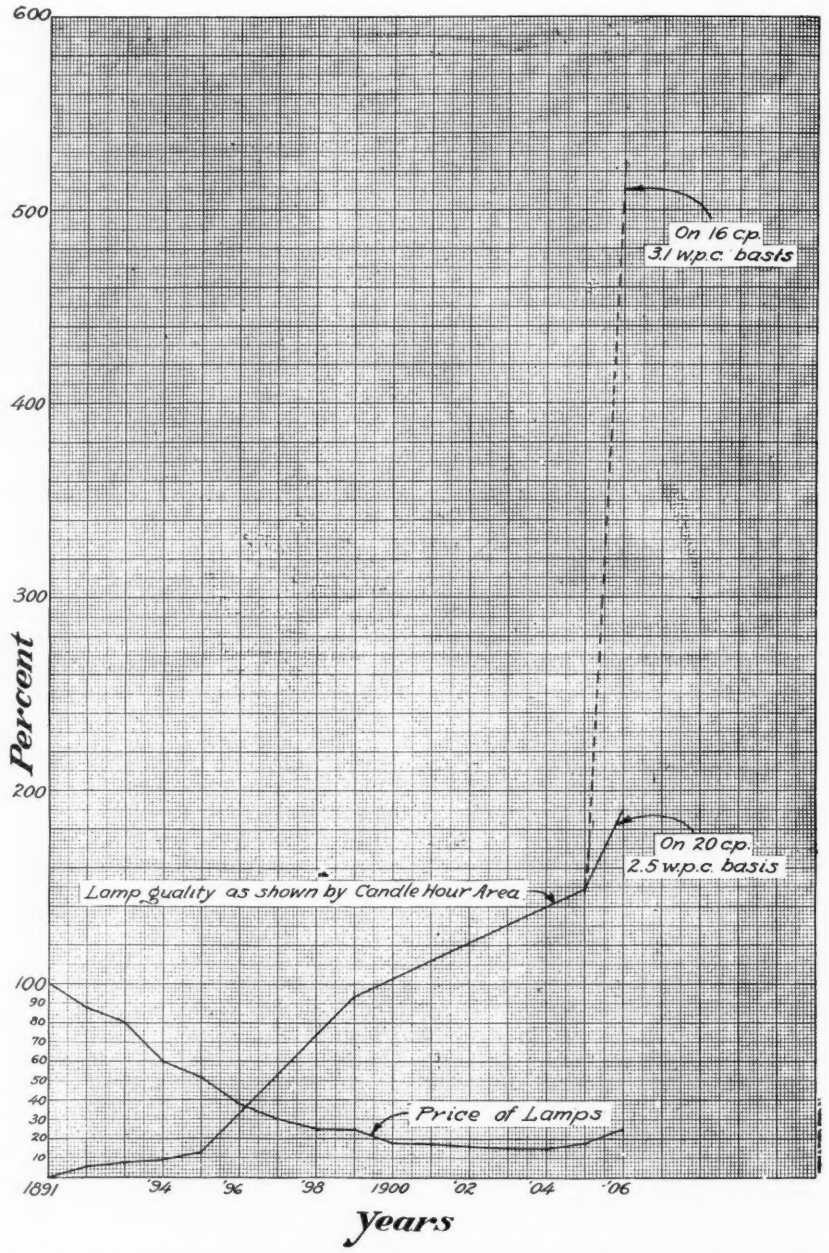


FIG. 2.—CURVE OF QUALITY AND PRICES OF EDISON LAMPS SHOWING VARIATIONS THEREIN SINCE 1891 AND THE LARGE RISE IN THE QUALITY CURVE OF 1906 SHOWING THE IMPROVEMENT CAUSED BY METALLIZING THE FILAMENT.

Designation in Fig. 1.	Description.	Cold.	At 3.1 W.P.C.
"A"	Base carbon not metallized.....	25,500	14,460
"B"	Base carbon metallized.....	24,900	10,460
"C"	Graphite shell not metallized.....	3,840	1,715
"D"	Graphite shell metallized on a base not previously metallized.....	514	1,283
"E"	Graphite shell metallized on a base previously metallized.....	954	1,530

This limitation is marked in case of very fine filaments so that the metallizing process, in common with other and later developments, appears to offer little or no improvement for 200-250-volt lamps.

The improvement obtained by metallizing the carbon filaments results largely from a reduction in blackening of the ordinary lamps. The loss of candle-power in the incandescent lamp is chiefly due to two factors, change of resistance of filament and blackening of the bulb. In the ordinary carbon filament about fifty-five per cent of loss of light is due to blackening of the bulb, and forty-five per cent to change in resistance, whereas in the metallized filament only twenty per cent is due to blackening and eighty per cent to change in resistance.

On the lamps thus far developed steady progress has been made, tests of the latest product showing an improvement of thirty per cent in life results over those obtained six months to a year ago. The improvements are of such a character as to hold out the hope of a possibility in time of an efficiency of two watts per candle with satisfactory life. So marked are the advantages of the carbon filament that an efficiency of two watts per candle, if possible, would probably enable it to effectually compete with any of the new metal filaments, such as the tungsten, now in course of development.

TANTALUM LAMPS.

The tantalum lamp was the first metallic-filament lamp to reach a commercial state. While tantalum is over a hundred years old, it has not been obtained in the pure form until recent years as the result of the experiments of Dr. W. von Bolton, of Berlin, who obtained it from an electrical furnace, with tantalum electrodes under vacuum. Prior to the experiments of Dr. von Bolton, the metal had not been drawn into wire and so had not been available for lamp filaments. Sufficient tantalum material has developed on search to provide an ample supply of the metal for filaments.

As is well known, tantalum has a tensile strength equal to that of the best steel. What makes it specially suitable for filaments is its high fusing point, 2,300 degrees centigrade, and high vapor tension point.

The construction of the tantalum lamp is now familiar to all from illustration and use. Each twenty-five-candle-power lamp contains about two feet of wire of very small diameter (0.0018 inch), so fine that filaments for some 20,000 lamps can be produced from a pound. At incandescence this filament softens to a considerable extent and it is necessary to support the filament about every inch to inch and a half of its length. This is accomplished by looping the wire back and forth through small hooks on the ends of radial-wire supports, which are in turn fused into a supporting glass pillar. While the tantalum filament breaks at times as a result of softening under incandescence, this quality also enables the filament to be readily repaired—a slight tapping of the bulb frequently causing the broken ends of the filament to weld together.

The tantalum lamp gives a more brilliant light than the ordinary carbon filament. The first tantalum lamps introduced were twenty-two-candle-power, forty-four-watt lamps, but American

FIG. 3.—G. E. TANTALUM MERIDIAN LAMP, 50 WATTS, 25 CANDLE-POWER; 80 WATTS, 50 CANDLE-POWER MERIDIAN RATING.

manufacturers of these lamps are now offering two sizes, consuming fifty and eighty watts respectively.

The fifty-watt lamp will enable stations to maintain their output per lamp the same as the sixteen-candle-power carbon lamp, and thus give customers fifty per cent increase in candle-power at no increased cost. This fifty-watt lamp will naturally be preferred by all stations which desire to maintain their output per lamp unchanged and to raise the standard of candle-power.

The eighty-watt tantalum lamp provides a good substitute for the ordinary thirty-two-candle-power carbon lamp, giving twenty-five per cent more light with twenty per cent less energy, and it also supplies an economical substitute for the regular 100-watt GEM-filament lamp, giving the same candle-power values, with similar Holophane reflectors, with twenty per cent saving in energy.

Both the fifty and eighty-watt tantalum filaments are supplied in the round bulb uniform with the regular Meridian type of lamp, and thus provide an ornamental form of lamp to overcome any objections on the score of appearance.

The life of the tantalum lamp on direct current is over 700 hours for the smaller size and 1,000 hours or more for the larger size lamp. On alternating current of twenty-five cycles the life is about two-thirds and on sixty cycles about one-half of the life on direct current.

Tantalum wire appears to be crystallized by the flow of current therein. The pulsations of alternating current produce a movement of the wire structure in the lamp, causing the crystallized sections of filament to slip past each other and to rupture the filament. On direct current there is little or no movement of the filament, so that it is held intact for a longer period. This is the explanation given by Dr. O. Feuerlein, associated with Dr. von Bolton in the development of this lamp. This explanation also shows how the reduction in life increases with the increase in frequency.

Such exceptional performances have been obtained from individual lamps as to indicate the presence of certain impurities in the wire which may be responsible for the shortening of the life of many of the lamps.

To the question whether the tantalum lamp will not have to give way to the superior efficiency of the tungsten, time only can give a full answer, but at present the tantalum lamp is available in commercial quantities while the tungsten is not.

The tantalum lamp is a more hardy and durable form of lamp than the present form of tungsten, and the tantalum lamp is also capable of production in multiple types for 100-volt circuits as low as twenty candle-power. All these special characteristics will, it is believed, provide a special field for the tantalum lamp and continue its use indefinitely.

TUNGSTEN LAMPS.

Tungsten (or wolfram) is a metallic element older than tantalum, as it was discovered in 1781 and named from the Swedish "tung" (heavy) and "sten" (stone). It is not found native, but occurs as the tungstate of iron and man-

ganese in the mineral "wolframite," and as the calcium tungstate.

The pure metal comes in the form of a powder, is a bright steel-gray, hard, brittle, crystalline substance—heavier than tantalum (specific gravity, 19.12). Its chief use in the arts has been to increase the hardness and tenacity of tool steel. Its fusing point, according to Waidner and Burgess, is 3,200 degrees centigrade, thus enabling it to be operated at the very high efficiency of one and one-quarter watts per candle, or about three times the efficiency of the average carbon lamp.

The reason why tungsten has not been employed for filaments before is largely due to the fact that it was not possible to draw it into a wire, owing to its brittle crystalline character. The actual production of the filament has been accomplished in a roundabout way, which in general may be described as follows:

The metal, in the form of a very fine powder or colloidal solution, is made up into a paste with a suitable binder, and when brought to a proper consistency is squirted through a die. The filament thus formed is then dried, the binding material worked out by a suitable process, and the particles of tungsten coalesced or "sintered" together by passing an electric current through them.

Tungsten filaments possess similar properties to those of tantalum—high conductivity and positive temperature coefficient, so that it is necessary to use very long, thin filaments for lamps of fairly low candle-power on 110-volt circuits. Filaments of lamps of about forty candle-power are only 0.0016 inch or 0.03 millimetre in diameter. A very fine hair measures 0.06 millimetre.

As in the case of tantalum, tungsten softens at incandescence, so that it is necessary to support the filament very carefully in order that it may be burned satisfactorily. The earlier lamps could not be burned in anything except a vertical pendant position, but the General Electric Company has made tungsten lamps with the filaments so anchored that they can be burned in any position. As may be seen from the illustrations the method of supporting the filament is quite different from that of the tantalum lamp, as the filament, instead of being in one continuous length, is composed of a number of loops, four or five of which are connected in series with each other. The ends of each loop are fused fast to the supporting wires connecting with the base of the lamp. As is the case with all metal-filament lamps, tungsten lamps can be produced to much better advantage in low voltages, below fifty volts. On the same basis, it would seem where multiple-voltage lamps are made, that it would be better to produce these in high candle-power sizes, as it does not at present appear practical to go below the minimum candle-power value of about forty.

The chief drawback to the lamp appears to be its fragility, which renders it liable to breakage in handling and transit. To transport these lamps safely, special precautions and great care in packing will be required, requiring packages of considerably larger bulk than are at present necessary with the ordinary lamps. Fig. 4 shows a consignment of foreign tungsten lamps—the greater bulk of the tungsten packages as compared with the carbon is very noticeable. With lamps of low voltage, filaments can be made comparatively heavier and shorter in length, and thus chances of breakage are reduced.

This feature of fragility, however, should prove but a temporary difficulty. Means will be devised to overcome it, as they were in the case of the Welsbach lamp. Anything more fragile than a Welsbach mantle would be hard to conceive, yet this delicate ashen fabric has been developed to the necessary degree of stability to make it commercially satisfactory.

It should be remembered that the first carbon filaments were so fragile that Edison and one of his assistants had to work continuously several days and nights to obtain a filament sufficiently stable to mount in a bulb. Fragile as the present tungsten filaments appear to be, they are more durable than the first carbon filaments were. In the light of such history and experience, there need be no dismay about the tungsten lamp because of its fragility.

The General Electric Company has made up a number of thirty-volt tungsten lamps (Fig. 5) which is expected to prove serviceable for train lighting. These lamps are rated at about twenty candle-power, twenty-five watts, and if they prove satisfactory should definitely settle the question of train lighting. While the majority of train-lighting service to-day is in the neighborhood of sixty volts, the system could readily be adapted to thirty-volt lamps by using the three-wire plan

FIG. 4.—PHOTOGRAPH OF CONSIGNMENT OF FOREIGN TUNGSTEN LAMPS SHOWING RELATIVE SIZE OF 100 THIRTY-TWO CANDLE-POWER TUNGSTEN IN HOGSHEAD AND 100 THIRTY-TWO CANDLE-POWER CARBON IN THE BOX.

he cars, or by running the lamps two series on fixtures provided therefor.

The low-voltage twenty-five to thirty-volt tungsten lamps have short filaments, and can be transported and handled with comparatively little breakage. The low-voltage also permits of low-candle-power sizes in the neighborhood of twenty candle-power.

These advantages will undoubtedly cause these low-volt tungsten lamps to be quite widely used in regular central station lighting service. Such lamps can be used four in series on regular 100-130-volt circuits, or where alternating current is available the voltage can be reduced to twenty-five or thirty volts by means of a special compensator or transformer, placed either in a wall cabinet or in the canopy of the fixture, or attached to the socket. The use of lamps four in series would seem to be practical in cases where cluster or fixture lighting is employed, as with such clusters of four lamps turned on and off at a wall switch it would not make any material difference whether the lamps were in series or in multiple.

To prevent any misuse of these low-volt tungsten lamps, and any trouble resulting from connecting them to the regular multiple circuit, it is proposed to provide these lamps with left-handed screw shells and to use left-handed screw-shell sockets on all low-volt installations.

The multiple 100-watt tungsten lamp is being developed for service, and with this lamp it is intended to employ the same bulbs as the regular GEM incandescent units, thus giving a tungsten unit of double the candle-power of the present 100-watt GEM-filament type. The tungsten lamp is also being developed for train-lighting and street-lighting service.

For street-lighting service, where low-voltage lamps are chiefly used, the tungsten lamp has a special merit, and will by reason of its high efficiency greatly promote the use of electric street incandescent lighting. From recent tests of some 200 thirty-candle-power 5.5-ampere tungsten series lamps on the series lighting circuits of the Public Service Corporation at Arlington, N. J., at an efficiency of one and one-quarter watts per candle, an average life of 1,350 hours has been obtained, and sixty-two of the original lamps have burned over 1,900 hours.

The tungsten lamp operates equally well on both alternating and direct current. The life of the tungsten multiple lamp approximates 1,000 hours.

As the GEM, tantalum and tungsten lamps all have positive temperature coefficients, this gives these lamps considerably better inherent regulation than the ordinary carbon-filament lamp, as the candle-power, energy, etc., undergo smaller changes with change in voltage than in the case of the carbon lamp.

The life of the tantalum and tungsten lamps is less affected by increased voltage than the carbon filament, but to exactly what extent the lack of exact data does not enable us to say at present. All this, however, has considerable practical value in reduction of copper required in circuits.

In the matter of price it is difficult to compare the tungsten lamp with the carbon lamp owing to the fact that the former is made in multiple types only in high candle-power sizes at present. Comparison of prices of tungsten series lamps with those of the carbon type, and of the tungsten high-candle-power lamp with similar size carbon lamps, shows that the present prices established on American

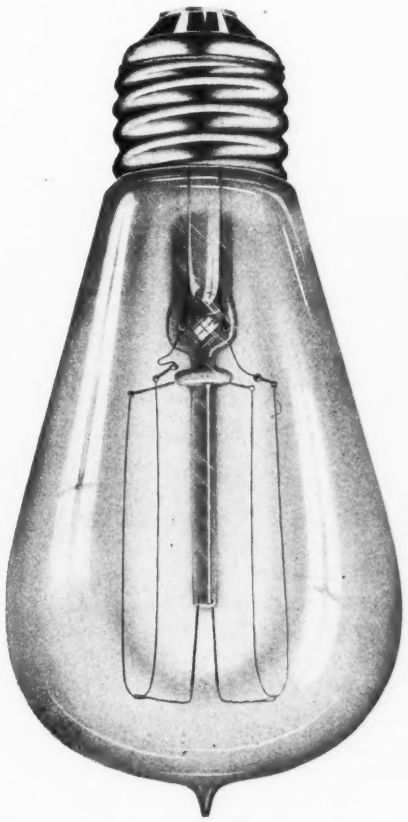


FIG. 5.—G. E. LOW VOLT TUNGSTEN LAMP, 25 TO 30 VOLTS, 25 WATTS, 20 CANDLE-POWER MEAN HORIZONTAL.

FIG. 6.—G. E. TUNGSTEN MULTIPLE LAMP, 100 TO 125 VOLTS, 100 WATTS, 80 CANDLE-POWER MEAN HORIZONTAL.

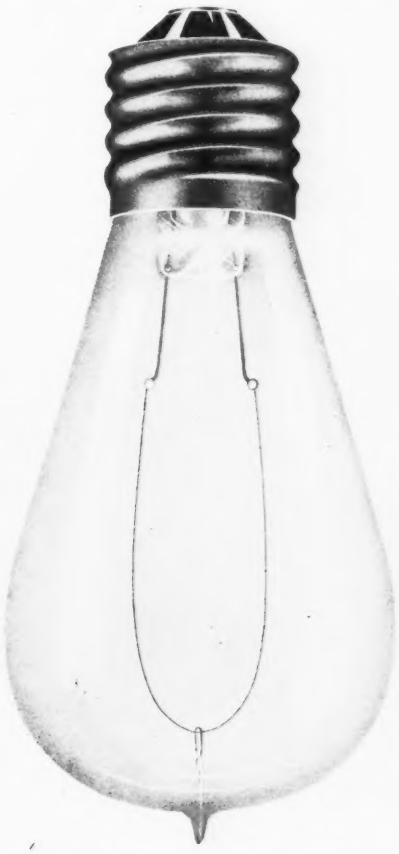


FIG. 7.—G. E. TUNGSTEN STREET SERIES LAMP, 40 CANDLE-POWER, 1.3 WATTS PER CANDLE.

lamps average about two to two and one-half times the price of the carbon lamp for equal life service. This increase in cost is very much below the value of the tungsten lamp as shown by the actual saving secured at average rates in force.

The improvement in efficiency in the tantalum and tungsten lamps is chiefly due to the higher temperatures at which it is practical to operate these filaments, although according to recent work of the National Bureau of Standards some improvement is also due to the selective radiation of these filaments. The marked gain in efficiency resulting from an increase in the temperature is evidenced by the fact that at the working temperature of these new metal lamps the intensity of the light emitted varies about as the twelfth power of the temperature, while the electric power supplied to the filament varies about as the fifth power of temperature. Dr. Ledever found in osmium lamps that the light increased as the 4.4 power of the voltage, while the power consumed varied only as the 1.5 power of the voltage.

Recent tests by the Bureau of Standards show that tantalum is more selective in its radiation than is tungsten, and very probably would be more efficient than tungsten at the same temperature, but the very high temperature at which tungsten can be worked continuously gives it the superior efficiency.

EFFICIENCY OF ILLUMINATION.

After all, it is not the efficiency of the lamps that we are so much concerned with as it is the efficiency of illumination, for, as has been truly said, as much and more depends upon the efficient use of a lamp as upon the efficiency of the lamp itself.

We are learning to pay more attention to the efficient employment of lamps so that the gains from the new high-efficiency lamps are multiplied again by the scientific reflection and distribution of light.

The use of scientifically designed and efficient reflectors, such as the Holophane, is greatly on the increase. A reflector is just as necessary to the lamp as the nozzle to the hose. Water will run out of a hose without a nozzle, but it can not be efficiently directed in a stream or spray, and so with a lamp—we need the reflector to direct and employ satisfactorily the light.

A long step in the practical betterment of electrical illumination was taken with the introduction of the Meridian lamps and "Incandescent Units" provi[ding] lamps with scientifically designed reflector and holder constructed to give the lighting distribution desired, and which can be installed to give uniform illumination under a simple law. Such a combination can hardly go wrong, as it insures results which the haphazard selection of reflectors and lamps could never give.

Our review of the incandescent-lamp developments shows that we are in an epoch of revolutionary changes, as the tungsten lamps have reached a standard three times better than our present lamps.

The efficiencies of all other forms of lamps, the arc, the Nernst, are surpassed. With the possible exception of the flaming arc and some forms of vacuum-tube lighting, the incandescent lamp with tungsten filament is the most efficient illuminant.

The incandescent lamp has always held the field against other illuminants by its numerous and well-known advantages, and now that its shortcomings in efficiency are corrected, and we are able to surpass other illuminants in this respect, the supremacy of the incandescent lamp and of electric lighting is established, and will usher in a new era of light and illumination before which all previous results will pale into insignificance.

Liverpool Electric Railways.

The report submitted by the traffic manager of the Liverpool & London, England, Corporation of Tramways, for the year ending December 31, 1906, shows a considerable increase in the traffic of this system. The number of cars in use was 475. The ratio of fatalities last year was one in every 30,000,000. Ten years ago it was one in 6,000,000. There were four fatal accidents caused by the cars, as against twenty-nine caused by other vehicles. The one-penny fares were about ninety per cent of the whole, or 108,900,000 out of 122,094,000. The average fare per passenger was 1.108 pence. The average length of the penny stage was two miles, 699 yards. The total length of track was 104 miles.

The total energy used during the year for railway purposes was 20,871,000 kilowatt-hours. These were purchased from the electricity department of the city at a cost of 2.22 cents per kilowatt-hour, this being a slight increase on last year's price. This price includes all charges in the delivery of the current to the section boxes. The average number of kilowatt-hours per car-wheel was 1.73, an increase of three per cent over the preceding year. This item has been increasing steadily for the past four years, being only 1.448 in 1903.

The increase in passengers carried from the preceding year was 2,970,000, or two and one-half per cent. The increase in receipts was about $68,000, also about two and one-half per cent. The increase in car mileage was 48,900 four-tenths per cent.

Illumination of Niagara Falls.

On the evening of Wednesday, September 4, the falls of Niagara were illuminated by means of searchlights located on the Canadian side, throwing the shafts of light on the American falls. The experiment was declared to be entirely successful, and will be continued for thirty days under the direction of W. D'A. Ryan, the illuminating expert of the General Electric Company. The different-colored lights were thrown upon the falls until a rainbow effect was produced.

The illuminating apparatus consists in part of three batteries of searchlights. In front of each projector there is placed a circular frame containing sheets of colored celluloid. The frame is revolved in front of the lenses, and the beams of light project from one-half to three-quarters of a mile to the falls.

The largest battery is on a platform in the main lower gorge, and consists of eighteen lamps with thirty and eighteen-inch projectors. Above this is the "cliff battery" on Table Rock, consisting of four thirty-inch projectors. A third battery soon to be installed will also be placed on Table Rock. This will be made up of four sixty-inch projectors.

The exhibition will be given from eight to nine every evening in September.

BOOK REVIEW.

"Tables for the Computation of Illumination." Compiled and published by William B. King. Dorchester, Mass. Flexible leather. 50 pages. 4¼ by 5½ inches. Furnished by the ELECTRICAL REVIEW for $2.

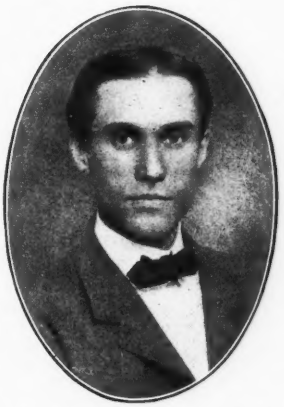
This book has been compiled to facilitate illuminating computations, and calls for simple multiplication only. By means of it, the illumination of any surface at any distance and direction from the source of light may be determined quickly. And, moreover, if the desired illumination be known, the necessary intensity of the source at any distance and in any direction may be quickly found. The tables are arranged giving the illumination due to a source having unit intensity in various directions, and at various distances, and the required intensity of the source to produce unit intensity of illumination at that particular spot. The tables are compiled for vertical distances of from one-half foot to thirty feet, and ingeniously arranged so that any particular table can be compared with that preceding and following it, without it being necessary continuously to turn over a page. To those who are called upon to plan lighting systems, these tables should be a welcome help.

Economical House Lighting.

By Van Rensselaer Lansingh, Illuminating Engineer.

HOUSES lighted by electricity can generally be divided into three classes. First: those where the question of economy plays no part whatever and where artistic effects combined with good illumination are the only considerations. Second: houses where illumination and economy are the only considerations and the artistic side of the question is almost entirely neglected. The third class lies between these two, where good and economical illumination are primary objects, but where the artistic side of the question is also considered.

The object of this paper is to take up the third class of lighting, and in order to make it of practical value a house has been selected, the lighting of which has been carefully designed by an illuminating engineer, with reference to getting the best illumination with the lowest operating cost; at the same time the design of the fixtures has been in keeping with the house without going to excessive first cost, most of the fixtures being of standard design. In such a case as this the first or installation cost is apt to run high, both with wiring and fixtures owing to the numerous outlets, but the decreased operating cost in a very short time will more than pay for the increased first cost. Thus, in the example herewith given, there are no less than seventy-four lights,



MR. V. R. LANSINGH, ENGINEER AND GENERAL MANAGER, HOLOPHANE COMPANY.

eight wall and floor receptacles for lighting and heating purposes and twenty-five switches for controlling the ceiling lights. The family occupying this twelve-room house numbers eight. Electricity is used exclusively for lighting and also largely for ironing, as well as for all the small electrical appliances which are now considered necessary in an up-to-date house. Although the rate is twelve cents net per kilowatt-hour for both heating and lighting, the largest bill so far rendered, which was for January, was only $9.60.

Inasmuch as it is possible to design the lighting of practically any house as economically and as satisfactorily as this example, it shows at once how the services of an illuminating engineer can be of great value to a central station, for at such operating costs it would be possible to add many new customers who are at present using other forms of illuminant.

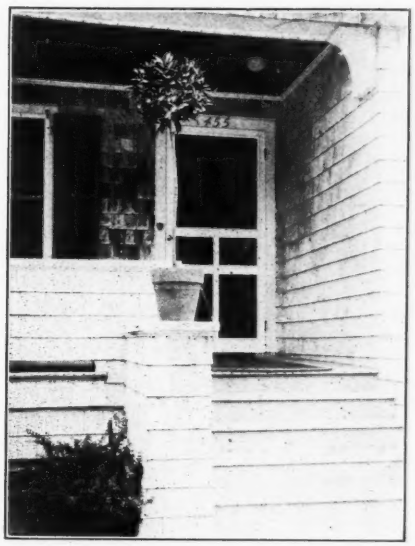


FIG. 2.—SHOWING PORCH LIGHTING.

FIG. 1.—GENERAL VIEW OF COLONIAL TYPE OF HOUSE.

Before taking up in detail the arrangement of the lights in this house, it would be well to consider a few general propositions. In the first place, it should be noted that long-burning lamps should, wherever possible, be of low candle-power. For example, porch lights, hall lights, etc., which are left burning most of the evening can be of low candle-power, not to exceed four or eight candles. On the other hand, short-burning lights, such as are used in closets, storerooms, etc., where

FIG. 3.—SHOWING LIGHTING OF HALL.

the light is only turned on for a few minutes but where during that time a good illumination is required, can be of much higher candle-power, anywhere from sixteen to thirty-two. By the rigorous adherence to this rule, economy of operation is possible.

Another consideration is that of switches. Every facility should be provided so that the user of the light will have a tendency to turn the same off when leaving the room. If it is inconvenient to do so, this will be neglected with the result of large electric bills. All ceiling or chandelier outlets should be provided with wall switches and all brackets with pull-sockets. Probably this feature alone will do more to lower operating costs than almost anything else which can be installed in house lighting, and the additional outlay will probably pay for itself in the first two years' saving.

Another thing is to provide a general illumination and, in addition, a local illumination in the special places desired. This local illumination can be of low-candle-power lamps and adds but slightly to the current consumed, but at the same time obviates the necessity for a high, general illumination, thus obtaining additional economy.

There is one further point to be carefully noted. The first installation may be equipped with proper-sized lamps, but unless care is given to the subject the renewal of such lamps is apt to be done with standard-sized lamps, which would, of course, very materially increase the bills. In such an installation, therefore, it is necessary that care be given to this side of the subject and that when a low-candle-power lamp burns out it be replaced with a lamp of similar candle-power.

With these points in mind, we will now take up the specific lighting of the house in question.

Fig. 1 shows a picture of the house itself. It will be noted that this is Colonial in design, and inasmuch as the interior of the house is along the same lines, the fixture design was planned with this in view.

Fig. 2 shows the lighting of the front porch. The objects of a light on the front porch can be summed up as follows:

First, to light the steps and porch so that one can easily see the same.

Second, to throw sufficient light on the caller so that he can be distinguished from the inside.

Third, to properly light the number of the house so that it can be seen at night.

FIG. 4.—SHOWING LIGHTING OF LIVING ROOM.

In Fig. 2 we see how this has been accomplished. A four-candle-power lamp has been placed in a prismatic reflector ball on the ceiling. This throws ample illumination on the steps and porch and at the same time lights the number above the doorway so that after dark it can be distinguished from the street forty feet away. This light is kept burning all the evening, averaging about four hours per night, so that the total operating cost is only about twenty cents per month. The cheerful effect which this small lamp

gives, not to mention its usefulness, is certainly worth the small sum which it costs, and if central stations could get their customers to use on porches small lamps, properly equipped, which could burn all the evening instead of, as is customary, a large lamp used only at short intervals, it would not only materially add to the lighting load but also improve the looks of the street and the lighting of the same.

HALL.

Fig. 3 shows the lighting of the hall, which is used purely as an entrance way

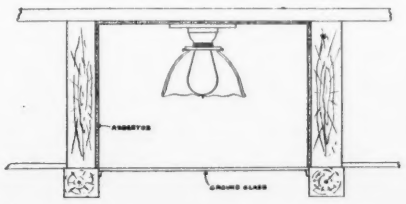


FIG. 5.—CROSS-SECTION OF POCKET FOR CONCEALED CEILING LIGHTING.

and not as a living room. The treatment of the hall is similar to that of the porch. A prismatic reflector ball, identical with the porch light except for the pattern cut on the bottom, is placed in a somewhat more ornamental holder, with a result that the hall is well lighted with only an eight-candle-power lamp. The position of the lamp inside the ball is such as to give a broad distribution of light, resulting in good illumination on the stairs as well as in the hall proper. This is a long-burning light, burning all evening, consequently the use of a small candle-power lamp is necessary and, in fact, gives efficient illumination for a cheerful and well-lighted hall. The walls in this case being of a gray paper and the ceiling white add materially to the illumination. If the walls and ceiling were extremely dark, it probably would have been necessary to use a higher-candle-power lamp. This brings up the question of illuminating engineers advising their clients generally as to the use of light-colored papers in houses so as to obtain increased illumination by this means.

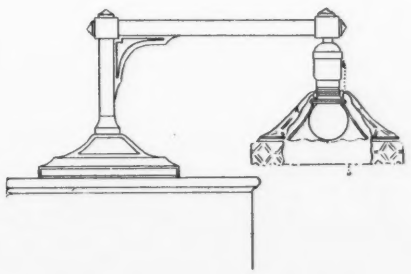


FIG. 6.—SKETCH OF PIANO LAMP.

LIVING ROOM.

Fig. 4 shows the living room with nine side brackets. It will be noted that these brackets are placed high and provided with pull-sockets. The object of placing these lights high is to get the benefit of a broad distribution of light. The globes are of a dense ground glass which, while giving rather a high percentage of absorption, diffuse the light to such an extent that it is not objectionable to the eye. While each bracket can be turned on or off by a pull-socket, they are all placed on one switch so that it is not necessary to turn each one on or off when entering or leaving the room.

In addition to the side brackets, there are three outlets in the ceiling (which,

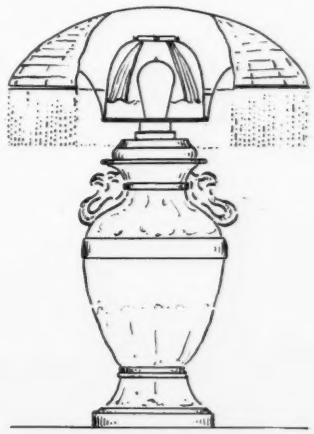


FIG. 7.—SHOWING EQUIPMENT OF TABLE LAMP.

however, are not visible in the photograph), one in the centre and one near each end of the room.

A pocket, shown in Fig. 5, is provided between the ceiling and the second floor, equipped with a twenty-candle-power Gem lamp, and a reflector giving a broad distribution so as to evenly illuminate the ground-glass plate below. The ground-glass plate is placed flush with the ceiling, and, inasmuch as the plaster between the beams is white, it is difficult to distinguish between the ceiling and the ground glass when not lighted. This gives the benefit, practically, of concealed lighting. Each light is controlled by a separate switch, and by this means efficient lighting is obtained in the room without the use of the side brackets. Thus chandeliers have been done away with entirely, giving an effect of spaciousness to the room, which is twenty-eight feet long and seventeen feet wide, which could not possibly be obtained if chandeliers were dropped from the ceiling. This also permits of lighting the centre of the room without the diffused light of the side brackets being necessary.

In connection with the side brackets, the location of the same should be noted. In the far end of the room is placed a long seat which is used largely for reading and lounging, and directly over each end is located a light which gives ample illumination for this purpose. The other lights are arranged around the room for general illumination. It should be noted that the two lights on each side of the piano are useless for the purpose of light-

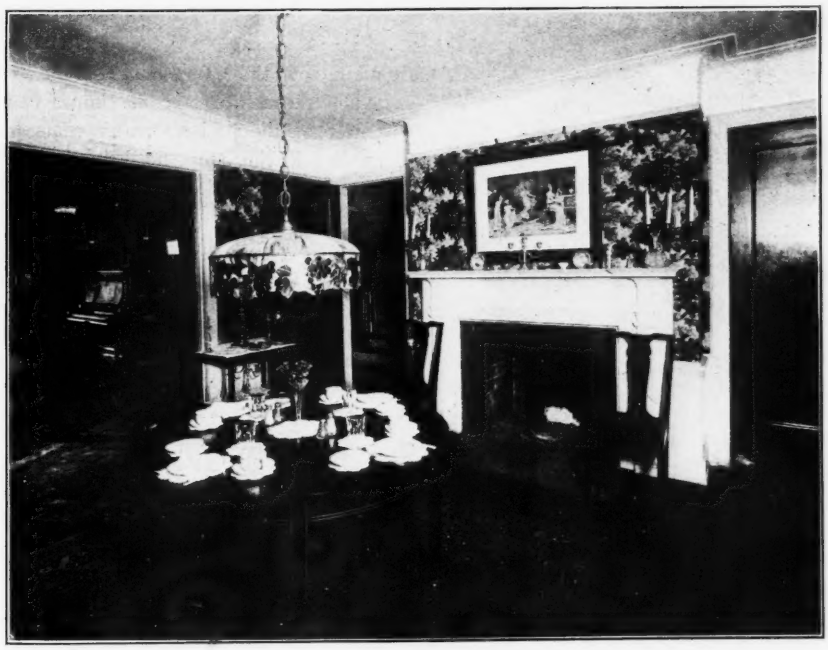


FIG. 8.—SHOWING LIGHTING OF DINING ROOM.

ing the music, as they do not project far enough forward, and there is, therefore, provided in addition a piano lamp, which, however, is not shown in the photograph. This lamp consists of a small art-glass dome with a sufficiently heavy base so that it can project over the music, and is provided with a pull-socket, a round four-candle-power lamp and prismatic reflector to throw the light down. A sketch of this lamp is shown in Fig. 6. This piano lamp is connected to a baseboard receptacle.

There is also provided on the table shown in the left-hand corner of the photograph a large electric reading lamp with an art-glass dome and equipped with a proper reflector to give a broad distribution of light so as to throw the same beyond the edge of the table. A sketch of the lamp and equipment is shown in Fig. 7.

It will be seen that this room is equipped with no less than fourteen lights, which can be turned on when desired, but in actual practice only three or four are found necessary for most purposes. On special occasions all the lights can be lighted, but the running cost under ordinary circumstances is low.

DINING ROOM.

Fig. 8 shows the dining room. The only light provided in this room outside of the sconces on each side of the mantle, consisting of real candles, is the art-glass dome over the table. This is hung at such a height that the lights are invisible to the people seated around the table.

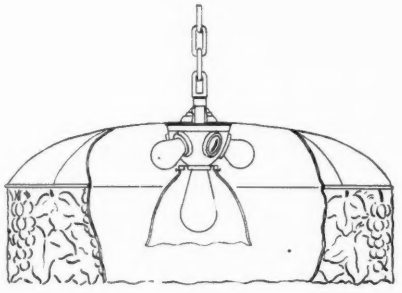


FIG. 9.—CROSS-SECTION OF DINING-ROOM SHADE.

The top of the dome is made of an amber-colored glass which allows considerable light to pass through, so that the room as a whole is well lighted, taking into account also the light reflected from the white tablecloth ordinarily used.

Fig. 9 shows a cross-section of the dome. The bottom light is controlled by a separate switch; it is equipped with a prismatic bowl-type reflector, giving a broad distribution so that the table is as well lighted at the edges as it is in the centre. This light is controlled separately from the others in the cluster by a switch placed close to the entrance to the pantry, and is the only one which is used by the maid in setting the table. As a matter of fact, with a white tablecloth this light is ample for all purposes with a fifty-inch table, and at the same time gives plenty of light throughout the room. In case the table is extended or more light is wanted in the room, a switch placed next to the living room controls five four-candle-power lamps. Ordinarily these are not used, as the single twenty-candle-power lamp with this arrangement gives ample light for a dining room seventeen feet square.

It will thus be seen that it is possible to light a dining room artistically at a very small expenditure of energy. So efficient is the arrangement that the centre light is kept burning during the evenings for the cheerful appearance it gives to the room, and the operating cost is only six-tenths of a cent per hour.

(To be concluded.)

The Flaming Arc Lamp.

By J. H. Hallberg.

ABOUT twenty-five years ago, when electric arc lighting was first made practical and arc lamps were installed in this country, the standard arc lamp unit consisted of a direct-current series lamp, operating at ten amperes with a potential drop of forty-five to fifty volts across the lamp. It is interesting to note that at the very beginning of arc lighting the 500-watt unit was adopted as a standard and still remains so to the present.

The 500-watt open arc lamp was rated at 2,000 nominal candle-power, and for a long time this rating has been in force, although tests with modern photometers and instruments have indicated that the actual candle-power of this lamp is only about one-half of the old rating.

In the open series arc lamp the carbons were placed one above the other and the light came almost altogether from the carbon crater. The positive carbon crater being the hotter was placed above the negative carbon, so as to secure maximum illumination in the downward direction. The potential drop of forty-five volts across the arc required only a three-thirty-seconds to one-eighth-inch carbon separation. It is evident that with such a short arc a great deal of the light from the positive crater was made ineffective by the negative carbon, which materially lowered the candle-power and introduced objectionable shadows below the lamp. The candle-power of the lamp also suffered on account of the impossibility of utilizing the light from the negative crater.

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The foregoing may in a measure explain how the 2,000-candle-power rating which represented the maximum candle-power of the positive crater came to be applied to the lamp, no deductions being made for reduction in the illumination of the lamp, due to interference and shadow from the negative or lower carbon.

That several designers of arc lamps appreciated this fact is evidenced by the records of the various patent offices. As early as 1882, patents were issued for arc lamps, having carbon pencils placed at an angle to each other with points downward, the object being to remove all shadows and increase the candle-power of the lamp, by securing all possible illumination from the arc as well as both craters. These same inventors also claimed the use of and applied an electro-magnet for blowing the arc downward below the carbon points to prevent the arc from creeping up on the inner side of the carbon. This magnetic "blow-down" maintained the arc at the extreme tips of the carbons, so that both craters were maintained flat, giving maximum unobstructed illumination. Notwithstanding

this early knowledge of high efficiency arc lighting, no serious attempts were made to develop and install lamps of this type. There is no doubt that the experiments at that time were frustrated by the absence of a cored carbon of good and uniform quality, which is necessary when the arc is operated under magnetic control.

Not until eighteen years later do the patent office records show a noticeable revival of interest in the arc lamp with carbons placed at an angle to each other, with points downward and magnetic "blow-down" for the arc.

In the meantime, foreign inventors were experimenting with and taking out patents on "electrodes for arc lamps" composed of an "intimate mixture" of carbon and metallic salts or metalloids, as calcium, magnesium, glass, fluor-spar, or the like, in combination with an addition of boron and fluorin.

The addition of these materials to the carbon would materially lower the resistance of the arc, permitting a comparatively wide carbon separation for a given voltage drop and there would be an extra yield of light from the arc in addition to the light from the craters. This new electrode could not be used as a practical proposition in the regular arc lamp with one carbon above the other, as during burning an insulating and incombustible slag is formed near the points of the electrodes, which seriously interferes with the operation of the lamp. The deposit is especially great on the lower electrode, as it drips on it from the upper one. This obstacle naturally led to the adoption of a lamp having electrodes placed at an angle to each other and points downward, so that the slag when formed could drip down in the base of the globe. The insulating slag at the points of the electrodes would however, not drop off altogether, so that when the lamp was turned off, the electrodes would not form contact to permit restarting of the lamp without first removing the slag deposit.

Difficulties of this sort led to the adoption of a special carbon-vibrating and arc-striking mechanism in the lamp to shake off the slag while hot or break it when cold. Experiments along these lines, conducted over a period of several years after 1900, did not prove very successful, only a limited number of flaming arc lamps, using these special, "intimately mixed carbon and mineral salt" electrodes, having been tried, in this country at least.

The large manufacturers of arc lamp carbons soon appreciated the great value of the flaming arc, but instead of working along the line of mixing mineral salts with the carbon for electrodes, developed a much simpler and more reliable electrode for flaming arc lamps. This was accomplished by simply squirting a regular carbon shell for a cored carbon and instead of filling the hole with the usual carbon mixture, a special filling of mineral salts, etc., was put in. It is evident that if any slag forms, it would be at the extreme ends and not on the side of the carbons, so that the slag does not interfere with the contact between the electrodes at starting, a clean carbon surface always being presented.

The placing on the market of such flaming arc carbons permitted the use of simpler and more reliable lamps which give a steady, shadowless and very powerful light.

The flaming arc lamp operates with an average arc voltage of forty-two and the current standard is about ten amperes for direct and twelve amperes for alternating current.

A carbon of comparatively small diameter must be used. Experience proves that one-millimetre cross-section per ampere is correct for the positive and about three-quarters-millimetre for the negative and for alternating carbons. With such thin carbons in an open arc lamp, the maximum life is one hour per inch of useful carbon.

Flame arc carbons at the present market price, consuming at the rate of one inch per hour, cost about one cent per hour per lamp. The life of one pair of carbons varies with their length. Lamps are made to give ten, fourteen and seventeen and one-half hours respectively, and the length of the lamp varies between thirty-two and forty-five inches.

Each lamp consumes about 500 watts, making the cost of carbons two cents per kilowatt-hour. The depreciation and repairs amount to the same as for any other form of arc lamp. The labor required for cleaning and trimming is the same as for the old style open arc, costing about two cents per trim, or an average of 0.14 cent per lamp-hour.

One 500-watt flaming arc lamp with yellow flame for general illumination will easily replace two open arcs of 500 watts each, or four enclosed arcs also of 500 watts each, provided, of course, that the flaming arc lamp can be hung as high as necessary in order to distribute the light properly.

The intensity of the flaming arc is so great that a light alabaster globe is preferable to clear glass. The flaming arc, although a very large unit, has a remarkable diffusing and distributing power. The peculiar clearness of color of the light from the flaming arc and the absence of all shadows, makes the light very attractive, and it is considered the best advertising medium, in the arc lamp line, at least, and is the greatest aid to the central station in fighting gas illumination.

The 500-watt flaming arc lamp gives practically the same volume and quality of light on alternating current as it does on direct, which is an important point in favor of its adoption by central stations supplying alternating current.

By reason of the fact that the greater part of the illumination comes from the arc flame, the flaming arc lamp may be used on much lower frequencies than other open or enclosed arc lamps. Lamps are in use on twenty-five and thirty-cycle circuits, showing less flicker than the enclosed arc with forty and fifty cycles.

The possibility of using flaming arc lamps on twenty-five-cycle circuits may in many cases induce adoption of this low frequency for general light and power distribution, which has heretofore been impossible on account of the unsteadiness and flicker when regular open and enclosed arc lamps are used. Large railway systems which have been electrified are using twenty-five cycles and future installations will perhaps use the same frequency. For illumination of such railway properties, the flaming arc is particularly adapted, and will permit the use of arc and incandescent lighting and power without the expense of installing and maintaining rotary substations.

The flaming arc lamp is not nearly so sensitive to voltage variations as the enclosed arc lamp. This is another point in its favor.

Flaming arc lamps are now available for practically all circuits. On constant-potential direct current each lamp requires fifty to sixty volts, operating two in series on 100 to 125 volts, four on 200 to 250 volts, ten on 500 volts, twelve on 600 volts and fifteen on 750 volts. When more than two lamps operate in series, an external automatic cutout with equalizing resistance is recommended with each lamp.

On constant-potential alternating current one lamp operates in multiple on fifty to sixty volts or two in series on 100 to 120 volts. When one lamp is to oper-

ate in multiple on 100 to 120-volt circuit, a small auto-transformer is required to reduce the line voltage to about fifty-five. On 220 and 440-volt circuits, lamps may be operated in conjunction with auto-transformers or other suitable compensators.

The flaming arc lamp operates on any frequency from twenty-five to 140 cycles. On twenty-five and thirty-cycle circuits, a carbon of smaller diameter is required, which reduces the number of hours' burning with one trim to a maximum of thirteen.

One American-made flaming arc lamp may be connected in series on 9.6-ampere constant-current arc circuit for street and commercial outdoor window-lighting. This same lamp operates, in combination with a small pole-transformer, in series on any constant-current series-alternating arc or incandescent lighting circuit for street or commercial lighting.

The American market has until recently been supplied with flaming arc lamps made in Germany, but now American-designed and made lamps can be had and at lower cost. The German manufacturers use what is known as the clockwork escapement feed, controlled by shunt and series coils, and each lamp has a cutout intended to protect the shunt-coils from burnout, in case the carbon should stick or be consumed before the current is switched off. Some of the American manufacturers have produced lamps without clockwork escapement feed and have adopted the clutch-sneak feed controlled by shunt and series coils. Whenever a shunt-coil is used its circuit must be opened automatically, if the carbons should stick or be consumed, which necessitates the application of a cutout.

Within the past six months a new type of American-made lamp has been put on the market, which operates in series or multiple without shunt-coils, clutches and automatic cutouts. This lamp has a gravity feed, controlled by a rib, or projection on one of the carbons, the lower point of which rests on a copper shoe. The other carbon hangs on the supported one and both feed together when the rib on the supported carbon is slowly disintegrated. The disintegration of the carbon rib is accomplished by feeding the current for the arc from the copper shoe to the carbon rib. The indirect heat from the arc and the weight of the carbons and their holders, pressing down on the rib, also assist in consuming it, causing an absolutely perfect and uniform feed without the slightest arc variation.

Wherever the flaming arc lamp has been introduced, its reliability and high efficiency has been appreciated, and present indications are that the flaming-arc-lamp business will develop in an industry of enormous proportions.

Up to within a short time, all flame arc carbons have been imported. Now, however, American carbon manufacturers are supplying these carbons, and continued experience in their manufacture and increased production ought to materially reduce the cost of carbons for flaming arc lamps.

A French Electric Villa.

A description is given here by Frederic Lees of the electrical villa which has been fitted up by Gëorgia Knap at Troyaes, an ancient cathedral town a few hundred miles from Paris. Mr. Knap is a mechanical engineer and believes that electric power will be used in various ways in the home of the future. Before describing in detail the fittings of this house, Mr. Lees points out the apparent lack of appreciation of modern home conveniences in France. Their apartment houses are frequently fitted up most luxuriously in many ways, and yet are not furnished with telephones, elevators, electric lighting, or even bathrooms. At Mr. Knap's villa a visitor who wishes to enter presses an electric button at the gate. If it be at night a search-light immediately flashes out, lighting him up, and a loud-speaking telephone asks what he wishes. By an ingenious arrangement of mirrors, the attendant at the house, about 300 yards away, is able to see who is at the gate. By turning a handle, the gate is opened and as the visitor enters it is closed again. On reaching the house, as the visitor enters the front door an electrically driven door mat automatically cleans his shoes. The rooms in the house are fitted up with electrical radiators, lamps, fans and all other conveniences. The equipment of the dining room is probably the most elaborate. A dumbwaiter, something like an ammunition hoist, rises from the kitchen to the table in the dining room just above. Around this table is a small grooved track. Meals are served without any servants entering the room. On a signal from the master of the house, each course rises through the dumbwaiter to the table, a trap door in the latter closing automatically after the dish has appeared. The latter then moves slowly around the table, stopping for each guest. It finally returns to the kitchen the way it came. Next, a receiver for the used dishes appears, makes a trip around the table, and disappears in this way as each course is served in turn, the one in charge having complete control of the dish, as he can cause it to move around the table or to turn on its axis. The heating and ventilating arrangements of this room are most complete. In the kitchen, all the work possible is done by electric power. Cooking is carried out on electric heaters and in electric ovens, automatic time attachments indicating when each dish is ready. Polishers, cleaners, dish-washers and other devices are driven by small motors. In the laundry adjoining there is a washing machine, a rinsing machine and a wringing machine, each driven by a small motor, but one hour being required to do all the family washing. The temperature is not only automatically controlled by heaters, but the ventilation is also carried out in the same way. Mr. Knap has drawn up elaborate plans for an electric villa in which the equipment is much more complete than that which he has installed in his own house. In this design the temperature of the house is controlled in summer as well as in winter, cooled air being circulated through the walls during the hot weather, and practically all the duties of the servants are performed by electrically driven apparatus.—*Abstracted from The Architectural Record (New York), September.*

Electrical Supplies for the Navy Department.

The Bureau of Supplies and Accounts will open bids in Washington, D. C., on September 17 for the following material: 1,800 carbon brushes, 300 double-pole cutouts, six 125-volt electric drills, 400 fuses, 775 pounds of sheet fibre, eight electric grinders, 800 electric lamps, 800 pounds of Manson friction tape, 250 pounds of cotton insulating tape, 150 pounds of fuse wire, 700 pounds of magnet wire, and a miscellaneous assortment of electrical supplies, including silk, cotton and linen-web tape. This is all for delivery at the New York navy yard.

Wireless Telegraphy.

A British consular report states that a wireless telegraph station has been established on high ground in western Dieppe, France, for experiments with the Artom system. Communication and experiments are proceeding with Havre, and the masts are being prepared for a station at Barfleur, France.

The Effect of Higher-Efficiency Lamps on Station Output and Income.

A Symposium from Central Station Men in the United States and Great Britain.

IN connection with the present issue of the ELECTRICAL REVIEW, no subject is of greater importance than the effect of the new higher-efficiency lamps upon station output and income. In order to secure an opinion on this matter the question was put to a number of men, prominent in central station operation both in the United States and in Great Britain, the communications from the latter having been obtained through our British correspondent, Albert H. Bridge. The replies to our question are based, in the main, upon an editorial which appeared in the ELECTRICAL REVIEW for August 10. The passages in this editorial which bear directly upon the question are as follows: "Two immediate and opposite effects can be foreseen. The introduction of the high-efficiency lamps will, in the first place, tend to cut down the current output of the station. On the other hand, the economy resulting from the better efficiency of these lamps as sources of light should reduce considerably the cost of electric illumination and thus tend to increase the station output by securing more customers. . . . It seems probable, therefore, that the first effect of the new lamps will be a reduction of the station output, to be followed by an increase in business as soon as the lamps have demonstrated their economy."

At present there seems to be a disposition to let matters shape themselves. In any event, there is apparent no apprehension as to any ultimate disadvantage to the central station. The attitude seems to be summed up something like this: "The new lamps are here; we'll make the best of it." Some of the communications follow:

EDISON ELECTRIC ILLUMINATING COMPANY OF BROOKLYN.

. . . I may say in general, however, that personally I have no fear as to the effect of the introduction of these lamps upon our revenue. Their supply will necessarily be limited at first, and the natural increase in the use of electric service due to the lowering of cost will more than make up for the reduction in current consumption. The past experience of all progressive companies shows conclusively that the lowering of the cost of service is the most helpful factor in increasing revenue, and the introduction of high-efficiency lamps should be welcomed by all companies as an essential advantage in the building up of permanently increased revenue.

W. W. FREEMAN,
August 29. Vice-President.

DENVER GAS AND ELECTRIC COMPANY.

Central stations have had some experience with the effect of higher economy and efficiency lamps on their output and sales. The new high-efficiency lamps now being brought out may seem to indicate a reduction in output, but a glance at the sales columns of past years in the central stations will reassure most managers. These figures show that higher efficiency means increased sales, and, usually, increased sales on present investment or to present users.

A further example is shown in the gas industry, where the incandescent burners promised to reduce the quantity sold for illuminating purposes. Statistics, however, show a decided increase in sales with the more efficient burners.

This would indicate that the standard of illumination is increasing even more rapidly than higher efficiencies.

A word of caution is offered in taking up many of the high-efficiency lamps which may now seem to have reached a point of commercial availability. I believe there is great likelihood of our making a mistake here and advocating some of the new methods before they have become valuable commercially.

FRANK W. FRUEAUFF,
Vice-President and Manager.
August 28.

BIRMINGHAM RAILWAY, LIGHT AND POWER COMPANY, BIRMINGHAM, ALA.

I would welcome any innovation or improvement which cheapens electric light service to the customer, or which makes it more desirable to him. The result will always be an extended field, increased usage and increased dependence on your service. I think it has never been the case that any such change has been wrought rapidly enough to produce any revolutionary effect, and it has been demonstrated over and over again that cheaper and more efficient service produces an immediate increase in usage.

J. A. EMERY,
Vice-President and General Manager.
August 23.

NEW ORLEANS RAILWAY AND LIGHT COMPANY, NEW ORLEANS, LA.

The development of high-efficiency lamps has been so rapid that we can hardly realize the change at this central station. We are going slow in the introduction of these lamps, but we realize that the time is approaching for us to take a stand in the matter. I have introduced a number to test their practical effectiveness, and there is no doubt that they have given great satisfaction wherever they have been placed. The claim that the loss of current so put on the station will be compensated by an increased number of customers owing to the better effects of the high illumination is yet to be proven. In stations which are making free changes of lamps, some plan will have to be adopted to equalize before any radical change can be made. We must go slow in the matter. The primary cost of these lamps also is a factor in lessening their purchase at this time.

JOSEPH H. DEGRANGE,
August 27. Second Vice-President.

ELECTRIC AND WATER COMPANY, GRAND RAPIDS, WIS.

It would seem to the writer that there can be no doubt as to the general benefit that electric lighting plants will derive from the installation of the higher-efficiency lamps, as it will enable them to compete with gas and other similar plants that are being installed throughout the country. Customers naturally will use more lamps when they become cheaper, and the same amount of capital invested in power plants will be able to cover larger territory.

The Electric and Water Company has been considering the advisability of adding to its plant, and the increase of the efficiency of the lamps will probably enable it to get along for several years without an addition. The Electric and Water Company of this city is a strictly cooperative plant, built up on what is known as the "Wisconsin Valley Plan," each consumer being entitled to purchase stock at par in accordance with the amount of current used by him. It also furnishes the city lighting and power for pumping at the city waterworks at actual cost.

The capital stock paid in is $16,000. We have accumulated a surplus of $23,000, which remains with the plant, the dividends being limited. This city has an option to purchase the plant at any time. At a recent election the question came up as to whether or not the city should take over the plant, and the result of the vote was to allow the management to remain as it is at the present. The effect of the present working of the plant is to have all the benefits that would be secured by a municipal plant and to keep the management out of politics entirely.

E. P. ARPIN,
August 22. President.

EDISON ELECTRIC LIGHT COMPANY, YORK, PA.

The new lamps will revolutionize things if they are found entirely satisfactory and can be sold at a reasonable price, but the price is against them in so far as they are sold at the present time, as well as the unreliability of the lamps. I do not think there are any of the new lamps which have sufficient life to justify the expenditure. I believe, however, that in course of time the tungsten will have much longer life, greater efficiency and greater economy than the ordinary carbon-filament lamp. When this time comes there will have to be a readjustment of the basis on which current for light is furnished.

W. F. BAY STEWART,
August 21. President.

THE SEATTLE ELECTRIC COMPANY, SEATTLE, WASH.

The introduction of the new lamps taking from one-half to one-third of the current required by the old lamps will be gradual, owing to the high first cost of the new lamps; this will prevent their general introduction, and in consequence the reduction of station output and income from existing business will be gradual.

The greater economy of these lamps will naturally effect the cost of lighting to the consumer, which will have a tendency to increase the consumption by old consumers and also increase the number of new consumers. The drift in our cities is toward more brilliant illumination and electric light display, and this tendency will be encouraged by the cheaper cost of the service to the consumer. Undoubtedly the final result will be to greatly increase and stimulate the use of electric lighting to such an extent that all losses in the beginning will be compensated for eventually.

Central stations furnishing free lamp renewals will confine themselves to the pres-

ent high-grade cheap lamps, at least until such time as the price of the new lamps permits their being furnished on the free-lamp-renewal basis.

The advantage to be derived from the introduction of the new lamps must be shared for some time by the central station and the consumer, or at least until such time as the changed conditions brought about by the introduction of the new lamps are adjusted to the lesser output and income of the central station.

J. FURTH,
President.

August 28.

The following represent a number of opinions recently expressed by English electricity supply and some other authorities on the probable effect of the new high-efficiency lamps upon the future of electricity undertakings in England. The opinions have been furnished direct by the engineers themselves expressly for the purpose of this article:

CITY OF BRADFORD, ENGLAND, ELECTRICITY OFFICES.

We have not, up to the present, had sufficient experience in Bradford with high-efficiency lamps to be able to judge the future effect of the same upon the station output and income. The tantalum lamp, in spite of its disadvantage in having to be run two in series, appears to be gaining ground, due, I think, to a certain extent to its novelty, but no other type of lamp seems to have yet caught on.

As matters are at present it would appear to be simply a question of taking money out of the pockets of the supply authorities and putting it into the pockets of the lamp-makers, as it is very doubtful, when the high price of the lamps is taken into consideration and breakages allowed for, whether there is much to be gained at the present time by the use of the high-efficiency lamps where the price of current does not exceed 4*d*. per unit, and in cases of long-hour consumers is considerably below this amount.

With regard to the future, I am of the opinion that, as far as consumers who are at present connected are concerned, the gain due to the higher efficiency will be devoted to the provision of more light and that, although the lamps will consume less energy per candle-power, higher candle-power lamps will be used.

This applies more particularly to shops, but I believe that even in the case of private houses the result will be the same, as of late years the incandescent gas mantle giving from forty to seventy candle-power has been used in the place of one or two sixteen-candle-power flat-flame burners, and people generally are becoming used to a considerably higher standard of artificial lighting.

Should this prediction be correct, it follows that the output for lighting purposes of electrical generating stations is not likely to be decreased, except perhaps temporarily during the period in which the high-efficiency lamps are showing their capabilities and before the results obtained from the same cause a number of new consumers to be connected.

THOMAS ROLES,
City Electrical Engineer.

August 20.

COUNTY BOROUGH OF HANLEY, ENGLAND, ELECTRICITY WORKS.

The experience in both London and here has shown that the income from lighting of most stations will remain more or less stationary, as the public demand a very much cheaper supply, and it is only by reducing the price per unit that the competition of incandescent gas can be properly met. Thus in the last few years the price has dropped from an average of 4*d*. or 5*d*. to an average of a little over 3*d*. In this district the price per unit for lighting purposes only has fallen by one-third pence in each of the last two years, and further reductions cause this fall to be continued. I find that, with the cheapening of the supply, the advantage of the Osram or other metallic-filament lamps is merely to increase the light—people putting in a nominal fifty-candle-power Osram in place of a carbon-filament sixteen-candle-power lamp. I do not think in the general result that the consumption of electrical energy will be seriously affected on existing consumers' premises, while the immensely better illumination obtained will bring other new customers from gas lighting.

C. H. YEAMAN,
Borough Electrical Engineer.

August 20.

BOROUGH OF HARROGATE, ENGLAND, ELECTRICAL ENGINEER'S OFFICES.

We have already a considerable number of metallic-filament lamps in this town which have been in use for six months, and their use is largely increasing monthly. So far as our experience goes, up to the present the natural expansion of business more than compensates for the reduced accounts from individual customers by reason of these new lamps being introduced.

In certain parts of the district where larger transformers were necessary some time back, we are finding that it is no longer necessary to buy larger transformers, due to the more efficient lighting and saving in current.

The seriousness of the position is not so marked as it would have been were it possible to make these lamps of small candle-power. We find that thirty-two-candle-power metallic-filament lamps are taking the place of ordinary sixteen-candle-power lamps, thus raising the standard of light. Another advantage we are finding is that in remote areas, and on networks where small cables are used, we need not supplement the network by increasing the copper, as metallic-filament lamps do not show the drop in voltage to the same extent that carbon-filament lamps do.

My view is that for the next year or two the tendency will be to somewhat decrease the sale of current; but the time will soon arrive when the extension of business due to the lessened expense of electric lighting will far outweigh any temporary loss caused by the transitional stage.

GEORGE WILKINSON,
Borough Electrical Engineer.

August 20.

BIRMINGHAM, ENGLAND, ELECTRICITY WORKS.

I do not think the effect of the new high-efficiency lamps will be detrimental to electric supply undertakings. So far we have not noticed any reduction in the receipts in Birmingham from this cause, although many of our consumers have substituted the new lamps. I think the reason is that many consumers, such as shopkeepers, have installed a larger candle-power and consequently the receipts for current remain approximately the same. The general use of these new lamps will, of course, reduce receipts, but I feel convinced that the greater economy of the light will lead to a large expansion of the lighting business. I find that when this economy is put clearly before a prospective consumer it is often the means of inducing him to adopt electric light, whereas he would not consider adopting the old four-watt lamps.

R. A. CHATTOCK,
City Electrical Engineer.

COUNTY BOROUGH OF BARROW-IN-FURNESS, ELECTRICITY WORKS.

The tantalum lamp has been adopted to a considerable extent in this town. Its effect upon the output and income of these works varies considerably according to the class of consumer, and it would be difficult, without making a very careful examination of each individual consumer's account, to say whether up to the present time the introduction of these lamps has resulted in an increase or decrease in output from these works. I have no hesitation, however, in saying that these lamps will ultimately be a great benefit to supply authorities. In the better class of shops, clubs, hotels, etc., where good lighting has for some time past been regarded as a necessity, there is no doubt that the introduction of the high-efficiency lamp has resulted in a considerable loss of revenue to the supply authorities; against this loss, however, must be set the greater satisfaction of the consumer with electric lighting, and the retention of certain consumers who might otherwise, for economical reasons, be induced to revert to gas lighting. The amount of this loss of revenue, of course, varies very considerably according to circumstances, but I may perhaps mention a typical case of a public building which has come under my personal observation. In this building I have had about 140 eight, sixteen, and thirty-two-candle-power carbon-filament lamps replaced by fifteen and one-half and twenty-three-candle-power tantalum lamps. The lighting has been greatly improved, the amount of light being on the average probably from fifteen per cent to twenty-five per cent better than previously; the consumption in electricity since the tantalum lamps were installed has been about thirty-five per cent less than during the corresponding period of last year, the hours of lighting being practically the same.

H. R. BURNETT,
Borough Electrical Engineer.

August 21.

CORPORATION ELECTRICITY WORKS, BOLTON, ENGLAND.

Ultimately I believe the result will be a very large increase in both output and income, as in England the main factor in keeping back the general adoption of electricity for illuminating purposes is, first, the question of price, gas being supplied at comparatively low rates, and secondly, the difficulty caused by the expense of wiring houses for electric supply that have already been supplied with gas, but I think that the latter difficulty will be overcome when there is a real urgent demand for electric supply for illuminating purposes.

A. A. DAY,
Borough Electrical Engineer.

August 21.

WEST HAM (ENGLAND) CORPORATION ELECTRIC SUPPLY.

The advent of the high-efficiency electric lamp is our most valuable aid to increased output and income. As an example: A district supplied by a feeder which was heavily overloaded was canvassed for the sale of Osram lamps with a view to bringing some of the load off the feeder. The first result of this was a slight reduction in the load.

Second—Within three weeks the increased popularity of electric light resulted in several new consumers coming on the main.

Third—The consumers getting used to the increased light of the high-efficiency lamps, using more lamps than before, increasing considerably the total number of lamps on the main as before the advent of the metal filament. These facts speak for themselves.

A. HUGH SEABROOK,
Engineer and Manager.

August 22.

The Helion Light.

By Walter G. Clark.

A NUMBER of years ago, the writer became impressed with the possibility of bettering the efficiency of conversion of electric power into light. The possibilities of gasous conductors and luminescent materials were worked over for several years and while some results were obtained which were more than interesting from a scientific point of view, the limitations were such, that it could be seen that it would be extremely difficult to produce commercial illumination by the method which seemed to come nearest to the direct conversion of electric power into light.

The ordinary incandescent filament lamp meets the requirements of commercial conditions in a very satisfactory manner, as the small units enable the engineer to secure a good distribution of light. The form of the lamp is such that it withstands mechanical strains, it is used in small units, so the failure of one or more units does not interfere with the remainder of the system.

The writer's work upon incandescent conductors began about seven years ago and for four years the work conducted in his own private laboratory in the West, but three years ago it was found that Professor Herschel C. Parker, of Columbia University, was carrying on an investigation of conductors at high temperatures along the same lines as the writer, and that each had secured data and experience of value to the other, so the laboratories were brought together and since that time investigations have been in progress continuously at Columbia University.

Our work has extended over practically every element whose physical properties gave any promise of success in both the metallic and non-metallic bodies. Extensive experiments were conducted with refractory metals, and while a number of them were capable of withstanding a temperature much higher than could be borne by the ordinary carbon filament, a comparison of the properties of metallic filaments compared with the properties of some of the non-metallic substances, convinced us that the proper line to work upon was for the production of some composite material which would possess as far as possible, the desirable features of both the carbon filament and the metallic filament. The following considerations were the basis of this reasoning:

CARBON FILAMENT.

The carbon filament is of sufficiently high resistance so that the voltage of an ordinary commercial circuit can be absorbed in a comparatively short filament and this, with a sufficient cross-section so that the carbon filament lamp is mechanically strong. The limitation on the filament is that when a current is passed through a carbon filament, the carbon begins to disintegrate at between 1,400 and 1,500 degrees centigrade (black body temperature) and the carbon which is vaporized or shot off is deposited upon the glass walls of the lamp, reducing the efficiency both by reducing the cross-section of the filament and by rendering the walls of the lamp opaque to visible wave lengths. The useful life of the lamp is determined by the time which a lamp will burn before the efficiency is thus reduced to a point at which it is more economical to purchase a new lamp than to pay for the extra wattage required.

DR. HERSCHEL C. PARKER, CO-DISCOVERER OF THE HELION LAMP.

MR. WALTER G. CLARK, CO-DISCOVERER OF THE HELION LAMP.

METALLIC FILAMENTS.

Comparing these characteristics of the carbon filament with the characteristics of the metallic filament, we have the following:

The conductivity of all of the refractory metals is considerably better than the conductivity of carbon. For this reason, a filament, to utilize the voltage of a commercial circuit, must necessarily be either very long or of very small cross-section. If the filament is made with a cross-section sufficiently great so that its mechanical strength will be satisfactory, it must have considerable length to provide enough resistance. This produces a lamp of much greater candle-power than is used in ordinary practice. If the filament is made of small cross-section so that a lamp of low candle-power can be produced, the filament is exceedingly fragile and provision must be made to support considerable length of a very delicate filament.

In considering the temperature characteristics of metallic filaments, this is distinctly positive, *i. e.*, the resistance is much less when the filament is cold than it is when hot. For this reason, there is a rush of current when the lamp is turned on. This is of course of small consequence with the individual lamp but would be of some importance in throwing in extensive circuits of all metallic filament lamps. This characteristic, however, has its advantage, as the resistance increases very rapidly with increase in temperature in consequence of which, the lamp is much better able to withstand an excessive voltage and a slight variation in voltage is less apparent in the light.

Another matter which demands consideration, is the fact that on account of the greater emissivity of the metallic filament at temperatures above incandescence, a greater per cent of the energy applied is given off as light.

The Helion filament is a composite filament in which the base used is a very small carbon filament. It is possible for us to use other bases, but the carbon seems best suited to the requirements. Under the method by which we now make the filament, the small carbon base is mounted in a treating jar very similar to the one ordinarily used in treating or flashing the carbon filament. In this treating flask, a

compound containing silicon is deposited upon the filament. For this purpose, we have developed apparatus which is very nearly as automatic as the method used in flashing the carbon filament. The material deposited is, apparently, at first carried into the carbon but as the process is carried further, the filament takes on a surface deposit. As soon as this occurs, the emissivity increases very greatly and the color of the light changes from the characteristic color of a carbon filament to a much whiter light and this with practically no change in temperature.

The filament is built up with this deposit until the desired resistance is reached when the current is cut off. The filament is then ready to be mounted in the ordinary glassware used for a carbon filament. The resistance of the Helion filament is sufficiently high so that we are able to utilize 110 volts in a single corrugated loop. That this filament exhibits the desirable characteristics above enumerated for both carbon and metallic filaments is evidenced by the fact that the filament has sufficient mechanical strength so that it is practically impossible to break it without breaking the glass enclosing the lamp.

The filament may be burned in any position and in some recent tests a temperature of 3,300 degrees centigrade was reached before the filament showed any very decided tendency to sag or soften. The curve shown here is a comparison of the emissivity, at varying temperatures, of the Helion lamp and a three and one-half-watt carbon filament lamp supplied by the Electric Testing Laboratories. The candle-power determinations were made at the Electric Testing Laboratories and the temperature determinations were made by means of the Fery absorption pyrometer at Columbia University.

It will be noted that at 1,380 degrees centigrade (black body temperature), the carbon filament lamp required practically nine watts per candle-power while at the same temperature the Helion filament required three and one-half watts. The carbon filament lamp was rated at three and one-half watts per candle-power. At this rating the temperature observed on the pyrometer was 1,510 degrees. To this figure should be added a correction for selective radiation. This we have found to be about 100 degrees, which would make the actual temperature of the filament operating at three and one-half watts 1,610 degrees, according to our observations.

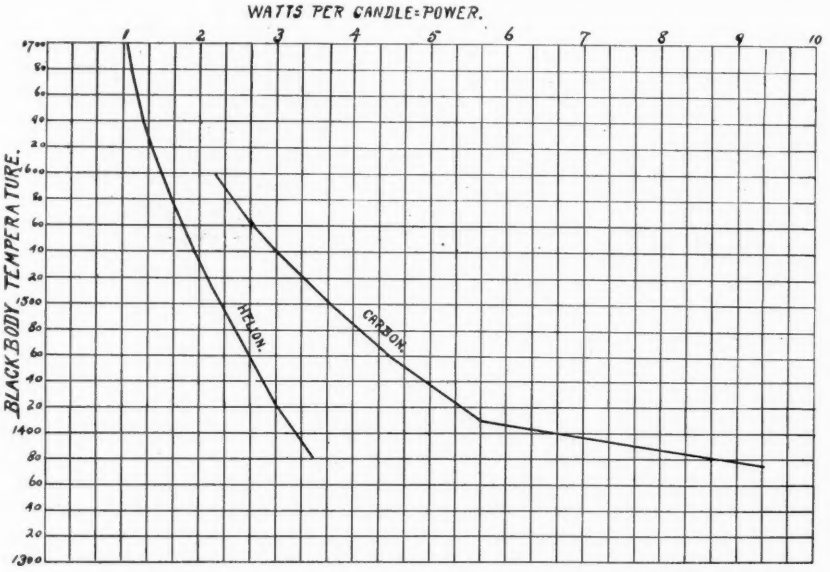
It will be noted on this curve that at 1,600 degrees (black body temperature) the carbon filament lamp required two and one-half watts per candle-power and the Helion filament lamp one and one-half watts per candle-power. At this temperature, the disintegration of the carbon filament was so rapid that the efficiency began to drop off materially, but the Helion filament at 1,700 degrees (black body temperature) consumed 1.07 watts per candle-power.

We have found that the Helion filament possesses a negative temperature coefficient up to about 1,350 degrees centigrade, at which temperature the coefficient becomes positive and from there on the filament exhibits a decidedly positive temperature characteristic, so in the Helion filament, we have both the negative temperature coefficient at starting, and the desirable positive temperature coefficient at the temperature at which the filament is to operate. Another feature possessed by the lamp is that the decrease in candle-power appears to be very slight so that our experience at the present time indicates that the lamp would operate up to a point where the filament parts, with a reduction in efficiency of less than five per cent.

The filament, on account of its positive temperature, coefficient when incandescent, withstands an overload remarkably well and an excessive voltage usually destroys the leading-in wires or the glass in the stem of the lamp without damaging the filament.

That the lamp is able to operate at an efficiency of better than one watt per candle-power in the larger-sized lamps, is indicated by the fact that we have operated a lamp of 400 candle-power at 300 watts for in the neighborhood of 300 hours in a very imperfect vacuum, after which the filament was taken down and examined, but aside from the oxidation due to the air present when the lamp was started, there was practically no change in the filament.

We have experienced considerable difficulty in producing a cement which would form a joint between the filament and the leading-in wire, as the ordinary carbon cement gives up a carbonaceous gas which is detrimental to the filament and reduces its life, but we have now produced a cement which appears to fulfil the requirements and we are engaged at the present time in developing commercial methods of manufacturing the filaments and the materials required in its production.



Curve Showing Emissivity at Various Temperatures of Helion and Carbon Lamps.

The filament possesses another advantage over the metallic filament in that it can be manufactured in a factory equipped for making the ordinary carbon filaments with but very slight change in the equipment, and on account of the increased proportion of blue rays in the light emitted by the Helion filament, the light approaches more nearly to direct sunlight than does any other lamp with which we have been able to compare it.

It is for this reason that we had the temerity to approach the name "Helios" in christening the new lamp the "Helion."

The Sirius Colloid Lamp.

By Paul McJunkin.

THE work of Dr. Hans Kuzel in the field of colloidal chemistry has been of the greatest value both to pure science and to electrotechnology. A number of scientists have worked with colloids and made many interesting observations regarding them, but few seem to have recognized the applicability of the study of colloids to a host of familiar but perplexing chemical phenomena, and much less the possibly great commercial importance which will result from the application of the principles of colloidal chemistry to the industries, until the announcement early in last year of the result of Dr. Kuzel's work in this field. The announcement of a one-watt-per-candle incandescent lamp awakened the most intense interest in electrical circles, but the method employed which made the result possible opened the eyes of the world to a new field of chemistry.

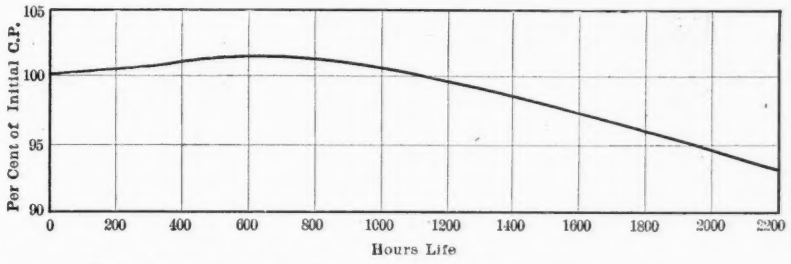


FIG. 1.—CANDLE-HOUR CHARACTERISTIC OF SIRIUS COLLOID LAMP.

A metallic-filament lamp of very high efficiency has been long sought. The difficulties have been chemical, in obtaining certain of the rare metals sufficiently pure, and mechanical, in forming the most desired metals into wires of sufficient strength to form a practicable lamp and of dimensions such as to make a low-candle-power lamp for the voltages generally in use. Decided steps in advance have been made from time to time as indicated by the tantalum, osmium, iridium, and most recently the tungsten lamps, with all of which there have been, unfortunately, some well-recognized weaknesses which have prevented their fulfilling the hopes and expectations of those who are waiting and working for the perfect lamp.

By reference to the "perfect lamp" I do not wish to imply that the product of Dr. Kuzel is properly described. It will be interesting, however, to analyze the Sirius colloid lamp as it is, as a basis for comparison with other existing lamps. The name Sirius colloid lamp is used to designate the product of a process which may be applied to any metal or metals which it may be desired to use, and by its use it has been possible to reduce all the rare metals to service as lamp filaments. By reducing the desired metal to the colloidal state it is possible readily to purify it to the highest degree, and while in the colloidal state it may be easily forced through the finest dies and thus made into threads or filaments of any desired diameter. The most important characteristic is, however, that the filaments formed by the reduction from the colloidal state to the crystalloidal state—which is the state in which we ordinarily know all the metals—is absolutely homogeneous. This term homogeneous is used not only chemically but physically, distinguishing the body to which it is applied from a drawn wire which, as is well known, is greatly modified on its surface. There is good authority for the assumption that this surface modification properly accounts for, or at least is intimately associated with, the less satisfactory performance of tantalum lamps on alternating than on direct currents. Again, the term excludes a filament made up of particles sintered together—a fair analogy being a rod forged from a solid-steel ingot and one forged from a lot of small scraps.

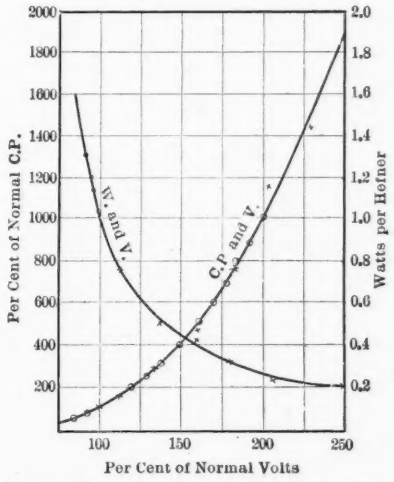


FIG. 2.—WATTS-VOLTS AND CANDLE-POWER-VOLTS CHARACTERISTICS OF SIRIUS COLLOID LAMP.

It is, however, the physical characteristics of the lamp and its electrical performance which are of vital interest. One of these life performances is the crucial test. Fig. 1 is based on tests made by the official laboratory of tests in Austria, where the most complete tests available have been made. The curve shown is believed to be fairly representative of the present lamp. Exceptional tests have been made showing a life of over 4,000 hours and practically without change in candle-power, which is a proper basis for expecting much improvement in the future.

The behavior of the lamps on abnormal voltage is also interesting. The chart, Fig. 2, is drawn from measurements made in Vienna by the writer last year. It is interesting to notice the extreme limit of efficiency recorded, *i. e.*, 0.2 watt per candle. At such efficiency the life is very short of course, being measured rather in minutes than hours, but it shows what severe electrical usage the lamps will stand momentarily without breaking down.

Although the manufacture under Dr. Kuzel's patent has not yet been begun in America, his lamps are being made to the extent of about 10,000 daily in three factories in Europe, so that the practicability of the lamps from a manufacturing point of view is thoroughly established. They are being shipped without difficulty, safe delivery being guaranteed.

Since the processes of Dr. Kuzel permits of the perfect manipulation of any metal or metals, it is very improbable that any further advance can be made along the lines of incandescent filament lighting than will be the outgrowth of the work already done.

The future of a one-watt-per-candle electric lamp in small units for commercial circuits is assured by the fact that it makes electric light the cheapest form of artificial light, while possessing so many advantages of safety and convenience over all others.

The Flaming Arc Lamp.

By Thomas Spencer.

A FEW years ago we frequently heard the remark that although great progress had been made in nearly every branch of applied electricity, as far as electrical illumination was concerned, practically no improvement had been made in the twenty years since its introduction.

During these long years of apparent inactivity in the development of electric lighting devices, illumination by means of gas was making very rapid strides due to the invention of the incandescent gas mantle by Dr. Auer von Welsbach, which very much increased the efficiency of gas as an illuminant and made it a serious competitor of the incandescent, and, to some extent, the arc lamp. This competition called very urgently for higher efficiency in both forms of electric lamps, and a great many inventors gave their attention to the subject.

In the early days of the development of the carbon-arc lamp, a great many lines of research were followed and a great many forms of lamps invented. Among the many things tried was the introduction of various salts into the carbon to increase the light-giving quality. This was suggested by the knowledge that salts introduced into the ordinary carbon arc would cause it to give the light which corresponded with the metallic base of the salt used, a fact which had been first utilized in the science of spectrum analysis. It was easily found that the metals of the alkaline earths, such as barium, calcium and strontium gave the best results. The great difficulty, however, was that these substances formed a slag which prevented the lamp's relighting after being turned off.

In America, very little improvement was made in carbon-making, but in Germany a very high degree of perfection was reached, especially in the cored carbons of Siemens. This invention did away with the unpleasant flickering which was supposed to be inseparable from an arc lamp, and those lamps using this form of carbon are so satisfactory that on the Continent they have not been superseded by the enclosed form, in spite of the frequent trimming which they require.

As the cry for more efficient lighting went up, it was natural that all avenues were searched for means to increase it. The first to revive the old idea of putting

Mr. Thomas Spencer, Chief Engineer, Helios Manufacturing Company.

salts of the alkaline earths in the carbons was Bremer, who exhibited a lamp in 1902 which used an electrode made by mixing salts of the alkaline earths with carbon. Bremer met with the same difficulty that all his predecessors had encountered: slag formed, preventing the arc from starting after it had once been extinguished. To overcome this, he invented innumerable devices to strike the arc, which only added complications without removing the difficulties. At this stage his experiments attracted the attention of the various carbon-makers on the Continent, and especially in Germany. These people, bringing to bear their great knowledge of the art soon discovered that they could overcome the difficulties which had been experienced by using a carbon containing a small amount of the light-giving salts introduced into the core of a cored carbon, at the same time keeping the size of the carbon as small as was consistent with a fair life. These principles in carbon construction coupled with the skill of the German arc-lamp makers has made this type of arc lamp universally popular on the Continent.

The highest efficiency is obtained by the salts of calcium alone, but the light is a golden-yellow. This was the form in which it was first sent out, but the carbon-makers, by a combination of other salts, have produced a carbon in which the yellow is less pronounced, at the same time not materially lowering the efficiency. Unlike other forms of colored illumination, the yellow light does not produce an unpleasant physiological effect; in fact, I have found this light rather more acceptable than some other forms which are much whiter.

With us the flaming-arc lamp, as it is called, is a newcomer, but it has made a good start, and as soon as its good points are fully appreciated, its use will be greatly increased; for as it stands to-day it is the most efficient form of lighting known, having a range in efficiency of between one-eighth and one-quarter watt per candle. That the life of the electrodes, being shorter than the life of the enclosed arc, may hinder its introduction in some places, is probable, but its high efficiency will at last triumph. As regards mechanical construction, the lamps used on the Continent which give the best results are those that adopted the plan first suggested by some of the early workers in the field, of forming the arc at the end of the two downwardly-pointing carbons at a slight angle to each other, and maintaining the arc at these points by means of electromagnets energized by the current.

The light of the flaming arc is derived from a glowing gas, a light of a different character from that given by an incandescent body—such as the carbon arc from an incandescent crater.

The light given by an incandescent body is always accompanied by rays which do not contribute to its light-giving qualities, but which represent radiated energy. In the case of a glowing gas, however, though only a few rays are sent out, all of them are usually luminous, so that the efficiency of sources of light which are based on glowing gas is the highest we have yet found.

The Germans, with their love of refinement, have stuck to the old form of clock-work lamps, which have gone entirely out of use in this country. Naturally, in devising flaming-arc lamps, they introduced the clock-work, so that the flaming-arc lamp first presented to the American market, being of German make, was of this type, and in consequence did not prove attractive. This objection is now removed and lamps with downwardly-pointing carbons having no clock-work are obtainable. In fact, in construction, some of them are no more complicated than those of the enclosed type.

With these changes in the construction of the lamp, which better fit it for the American market, I see no reason why it should not become as popular in this country as it is abroad, where it seems to have become the most popular form of illumination for all places where general lighting is required.

INCANDESCENT ELECTRIC LAMP MANUFACTURERS OF THE UNITED STATES.

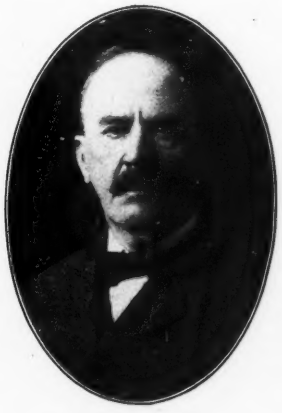
The portraits shown on the following four pages are of the representative men, executives and sales managers, of the manufacturing incandescent lamp companies. This is one of the youngest of the industries, though it has rapidly risen to large proportions, both in capital invested and people employed. The United States census figures for 1905 show a total output for that year of 114,296,053 incandescent lamps. The figures for 1900 are given as 25,717,630. It is estimated that the output for 1907 will be well over 200,000,000 incandescent lamps.

MR. J. AUERBACH,
President, Electrical Accessories Company, New York City

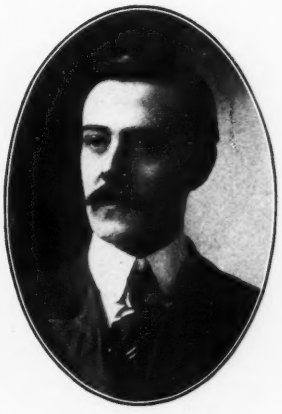
MR. J. F. BONNELL
President, Monarch Electric Manufacturing Company, Warren, Ohio.

MR. WALTER CARY,
General Manager, Westinghouse Lamp Company, New York City.

MR. WILLIAM COALE,
Treasurer, Sterling Electrical Manufacturing Company, Warren, Ohio.



MR. J. B. CROUSE,
Member Advisory Board, National Electric Lamp Association, Cleveland, Ohio



MR. J. B. ESTABROOK,
Sales Manager, Colonial Electric Company, Warren, Ohio.

MR. J. C. FISH,
President, Shelby Electric Company, Shelby, Ohio.

MR. A. C. GARRISON,
President, Columbia Incandescent Lamp Company, St. Louis, Mo.

MR. H. H. GEARY,
Treasurer and General Sales Manager, Fostoria Incandescent Lamp Company, Fostoria, Ohio.

MR. E. W. GILLMER,
Secretary and Treasurer, Warren Electric and Specialty Company, Warren, Ohio.

MR. J. P. GILBERT,
Secretary and Treasurer, Standard Electrical Manufacturing Company, Niles, Ohio.

MR. HENRY HASTINGS,
Treasurer, Re-New Lamp Company, Boston, Mass.

MR. E. H. HAUGHTON,
Manager, Bryan-Marsh Company, Chicago, Ill.

MR. CHARLES I. HILLS,
President, Franklin Electric Manufacturing Company, Hartford, Ct.

MR. CHARLES T. JAEGER,
Manager, Jaeger Miniature Lamp Company, New York City.

MR. HERMAN J. JAEGER,
President, Tipless Lamp Company, New York City.

MR. E. J. KULAS,
Secretary and General Manager, Brilliant Electric Company, Cleveland, Ohio.

MR. W. GEORGE LANE,
Sales Manager, Economy Electric Company, Warren, Ohio.

MR. G. G. LOCKWOOD,
Manager, Bryan-Marsh Company, New York City.

MR. H. W. McCANDLESS,
President, H. W. McCandless & Company, New York City.

INCANDESCENT ELECTRIC LAMP MANUFACTURERS OF THE UNITED STATES.

MR. JASPER MARSH,
Treasurer, Consolidated Electric Lamp Company, Danvers, Mass.

MR. R. K. MICKEY,
President, Novelty Incandescent Lamp Company, Emporium, Pa.

MR. R. W. MORGAN,
President, Anchor Lamp Company, New York City.

MR. GEORGE F. MORRISON,
Manager Lamp Works, General Electric Company, Harrison, N. J.

MR. CHARLES F. MUNDER,
President, Munder Electric Company, Springfield, Mass.

MR. E. E. NASH,
Sales Manager, Warren Electric and Specialty Company, Warren, Ohio.

MR. N. L. NORRIS,
Secretary and General Manager Banner Electric Company, Youngstown, Ohio

MR. W. D. PACKARD,
Secretary, New York & Ohio Company, Warren, Ohio.

MR. A. D. PAGE,
Manager of Sales, Incandescent Lamp Department, General Electric Company, Harrison, N. J.

MR. W. J. PHELPS,
Vice-President, The Phelps Company, Detroit, Mich.

MR. C. J. PURDY,
General Manager, American Incandescent Lamp Company Philadelphia, Pa.

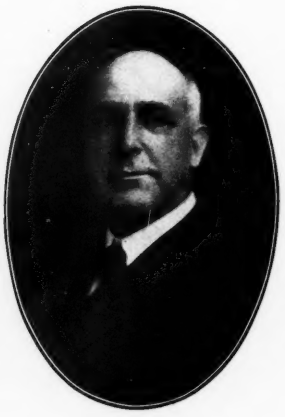
MR. H. C. RICE,
Vice-President, General Incandescent Lamp Company, Cleveland, Ohio.

INCANDESCENT ELECTRIC LAMP MANUFACTURERS OF THE UNITED STATES.

MR. JOHN ROONEY
President, Rooney Electric Lamp Company, New York City.

MR. LEROY P. SAWYER,
Treasurer and Manager, Buckeye Electric Company, Cleveland, Ohio.

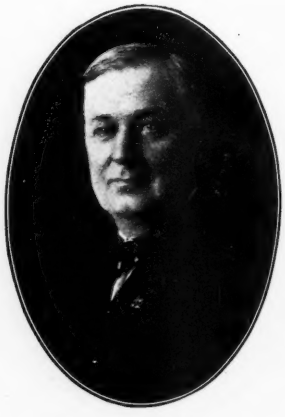
MR. EDWARD F. STRONG,
Manager, Boston Incandescent Lamp Company, Danvers, Mass.



MR. A. S. TERRY,
Treasurer and Manager, Eastern Sales Department, Sunbeam Incandescent Lamp Company, New York City

MR. F. S. TERRY,
Member Advisory Board, National Electric Lamp Association, Cleveland, Ohio.

MR. B. G. TREMAINE,
Member Advisory Board, National Electric Lamp Association, Cleveland, Ohio.



MR. H. A. TREMAINE,
Member Advisory Board, National Electric Lamp Association Cleveland, Ohio.

Hallery, Evanston.

MR. H. B. VANZWOLL,
Secretary, Sunbeam Incandescent Lamp Company, Chicago, Ill.

MR. C. R. WOOD,
Sales Manager, Moline Incandescent Lamp Company, Moline, Ill.

MR. JAMES C. WORMLEY,
President, Downward Light Electric Company, New York City.

INCANDESCENT ELECTRIC LAMP MANUFACTURERS OF THE UNITED STATES.

Photometry at the Bureau of Standards.

By Dr. Edward P. Hyde.

ON July 1, 1901, in accordance with an Act of Congress passed the preceding March, the Bureau of Standards was established to supersede the old office of Standard Weights and Measures, which prior to that time, in a restricted way, had performed the functions of a national standards laboratory. By the terms of the Act the functions of the new Bureau were to "consist in the custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government; the construction, when necessary, of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connection with standards; the determination of physical constants and the properties of materials, when such data are of great importance to scientific or manufacturing interests, and are not to be obtained of sufficient accuracy elsewhere."

From a humble beginning with a personnel of fourteen men, and with temporary quarters in the buildings of the Coast and Geodetic Survey, the Bureau of Standards has developed into an institution with a force of 110 employés, and occupying three new laboratory buildings situated on a seven and one-half-acre tract in the northwestern suburbs of Washington.

Harris & Ewing, Washington, D. C.

DR. E. P. HYDE, PHYSICIST, NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

The work in photometry was inaugurated in the fall of 1902 in one of the basement rooms of the Coast and Geodetic Survey building. For nearly two years it engaged the attention of only a single laboratory assistant, but in the spring of 1904, the photometric section moved to more commodious quarters in the new Mechanical Laboratory, and since that time the growth has been more rapid. At present the work is carried on by an associate physicist, two assistant physicists, a laboratory assistant, and a laboratory apprentice.

EQUIPMENT.

The photometric equipment consists at present of one standard photometer, one Matthews integrating photometer, one commercial photometer, one spectrophotometer and various auxiliary photometric and electric apparatus, which will be described briefly in the following paragraphs.

The standard photometer bench (Fig. 1) is used in all work on standard lamps, and in the investigation of special problems. The photograph from which Fig. 1 is made was taken when the bench was set up for the investigation of Talbot's law, in which Nernst glowers, covered by cylindrical hoods were used as sources. One of the hoods is shown in position; the other is sitting on the table beside the bare filament.

The bench is of the Reichsanstalt pattern, supplied with a Lummer-Brodhun contrast screen. By the use of a sufficient number of diaphragms covered with black velvet and suitably placed, stray light is excluded to such an extent that the leakage of light into the photometer screen is entirely negligible, although the walls of the room are of a light color. The comparison lamp, on the right, is mounted on a carriage, which is connected by means of adjustable links to the carriage supporting the photometer screen. The comparison lamp thus moves with the screen, remaining at a constant distance from it,

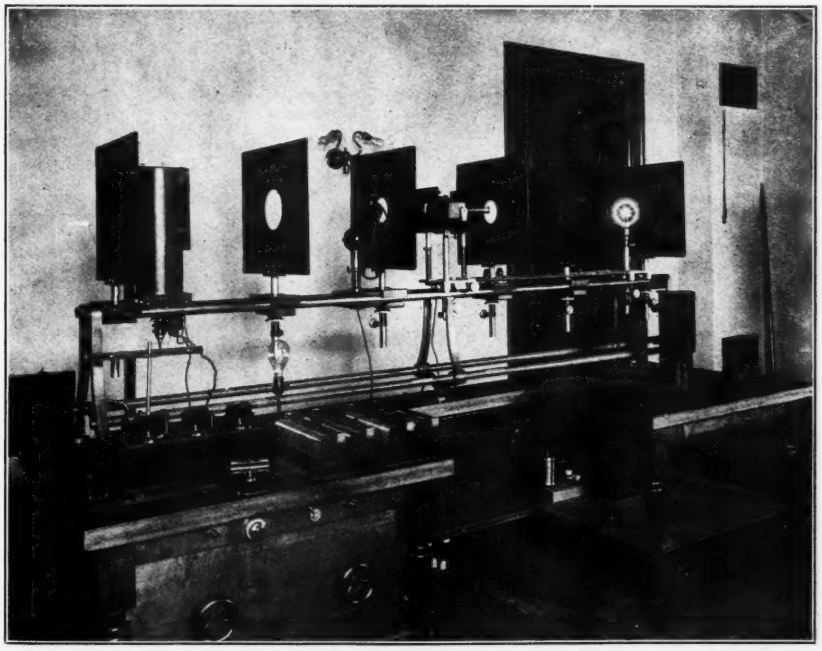


FIG. 1.—STANDARD PHOTOMETER BENCH, NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

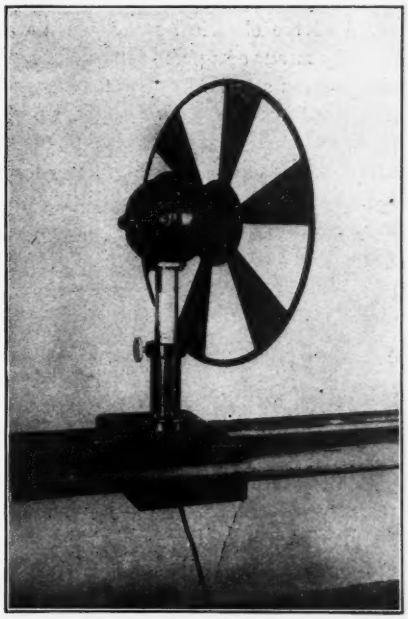


FIG. 2.—SECTORED DISC MOUNTED ON PHOTOMETER BAR, NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

so that the illumination on the right side of the screen remains constant during a series of measurements.

The standard and test lamps are placed successively in the socket on the left, and measured either stationary or rotating, as occasion may demand. The horizontal rotator (shown in the photograph with the driving shaft disconnected) was designed and constructed at the Bureau. It has four rotating mercury contacts, two for current and two for voltage. The shell and the base of the socket are each divided into two parts, insulated from each other, to one of which the current lead is connected, and to the other the potential lead. In this way the voltage is measured on the base of the lamp, reducing greatly any error that may be due to a bad contact between the base of the lamp and the socket.

The sectored disc shown in the photograph is used when rotating to reduce the apparent intensity of a source by a known amount. It is one of the most convenient instruments in a photometric laboratory, and is used extensively in the work at the Bureau. In Fig. 2 this disc is shown on a large scale. It is mounted directly on the shaft of a small motor. In a subsequent paragraph a new form of disc will be described, and the investigation of Talbot's law will be referred to.

All of the electrical measurements are made by means of a potentiometer in terms of a Weston standard cell. The voltage of the lamps is reduced by a suitable multiplier, and current is determined by the fall in potential across a standard resistance. By means of a convenient multiple switch, mounted in front of the potentiometer, voltage or current on either lamp can be determined quickly with an accuracy of one or two parts in 10,000. The galvanometer is mounted on the wall several feet behind the bench, but the spot of light is focused on a graduated scale right behind the potentiometer, and at a convenient height for observation.

A new universal support and rotator recently constructed at the Bureau (Fig. 3) may be mounted on one of the standard carriages belonging to the bench, for determining distribution curves around incandescent lamps. This instrument may be used either as a universal rotator, or as a universal lamp holder, since it is provided with two graduated circles in planes perpendicular to each other. A lamp may be set quickly to any latitude and azimuth, with an accuracy of a fraction of one degree. The axis of rotation is horizontal, making possible the use of mercury contacts. Any lamp from four candle-power to a hundred candle-power can be measured, and many types of reflector shades and diffusing globes can be mounted with the lamps. By means of an adjustable counterpoise the instrument is always in equilibrium, and therefore free from mechanical strains.

In Fig. 4 is shown the integrating photometer for the direct measurement of mean spherical and mean hemispherical candle-power of incandescent lamps. It is of the Matthews pattern modified in theory and construction. It is ten and one-half feet high, and is provided with twenty pairs of mirrors. It is installed in a room by itself, and although the walls and floor are as nearly dead black as could be procured conveniently, black velvet has to be used freely in order to eliminate stray light. The black velvet was removed when the photograph was taken. The instrument is at present provided with an equality Lummer-Brodhun photometer screen, but this will be replaced shortly with a contrast screen. The test lamp is mounted in a special form of rotator, which has two sockets—one upright and one inverted, so that the new types of lamps with weak filaments can be mounted and even rotated at a low speed. The comparison lamp is moved back and forth by means of a graduated steel tape, on which the distance is read. Voltage is measured on a laboratory standard voltmeter, and current by means of a millivoltmeter and shunt.

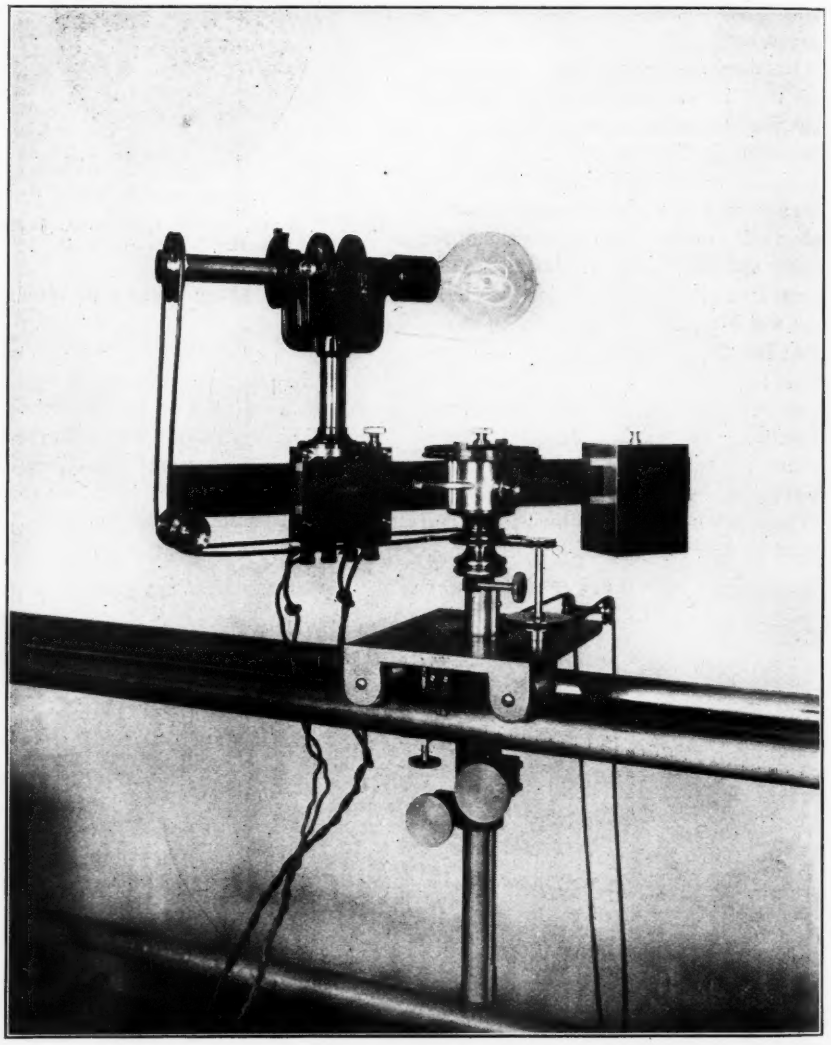


FIG. 3.—UNIVERSAL SUPPORT AND ROTATOR FOR INCANDESCENT LAMPS, NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

The commercial bench (Fig. 5), set up in the same room with the standard photometer, is used principally in testing samples of lamps purchased by the Government departments. This bench was specially designed and constructed in the

instrument shop of the Bureau. The horizontal rotator, mounted on the left, was purchased from the General Electric Company. It is equipped with the ordinary treadle for reversing the direction of rotation, so that lamps can be spun into and out of the socket. To the left of the horizontal rotator is a special end-on rotator made at the Bureau, for the purpose of determining the candle-power of lamps in the direction of the tip, since this is frequently specified in the purchase of incandescent lamps. This end-on rotator is driven by means of a belt running over a pulley on the vertical shaft of the horizontal rotator, so that both are driven by the same motor, and at the same speed, direct and reversed. Both rotators are provided with mercury contacts.

The comparison lamp is mounted in a fixed position at the other end of the bench, and the voltage on this lamp is adjusted until there is a balance against the standard lamp when the photometer screen is placed at sixteen candle-power, or at the proper point on the scale corresponding to the candle-power of the standard lamp. The screen is moved back and forth over a limited distance by means of a belt operated by a wheel situated under the table, and in a convenient position for the hands of the observer.

A new feature of this bench is the multiple candle-power scale, which in conjunction with a variable rotating sectored disc, permits of direct candle-power readings for lamps of all intensities, without moving the photometer screen over any great range of distance. One of the pieces of steel tubing forming the track is slotted, and within this tube is mounted a rotating drum graduated with five or six different candle-power scales, and operated by means of a thumb-screw. By turning the drum the desired candle-power scale can be brought beneath the slot. If fifty-candle-power lamps are to be measured, the variable disc is set to the proper angular opening and rotated, and the fifty-candle-power scale is used. The intensities of lamps in the neighborhood of fifty candle-power can then be read directly without moving the photometer any considerable distance from the central position. This latter feature is a distinct advantage, on the ground both of accuracy and of convenience. When lamps of a lower candle-power than sixteen are to be measured, such as eight-candle-power, or four-candle-power lamps, the sectored disc is placed on the other side of the screen, between it and the comparison lamp.

The voltage measurements are made by means of a deflection potentiometer recently designed at the Bureau by H. B. Brooks. With this instrument the voltage can readily be adjusted to 0.1 volt or better in less time than it takes to make a corresponding adjustment with a voltmeter, and the accuracy of the instrument is much higher. The energy supplied to the lamp is measured on a Weston wattmeter.

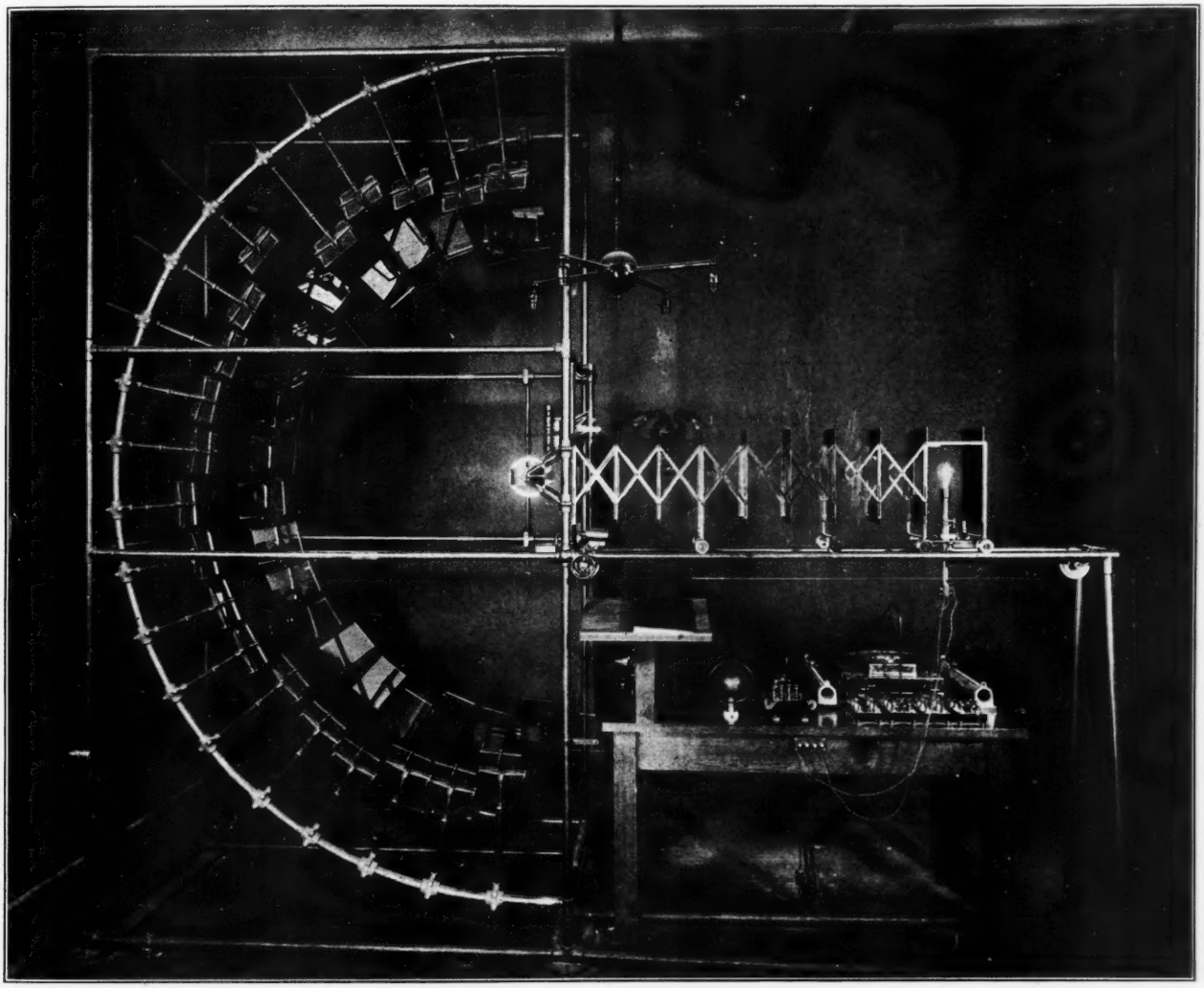


FIG. 4.—MATTHEWS INTEGRATING PHOTOMETER, NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

This instrument, in connection with a variable resistance, controlled by the position of the photometer screen, permits of direct readings of watts per candle. In series with the pressure circuit of the wattmeter are two resistance blocks, bridged by a sliding contact, fastened on the moving carriage, which holds the photometer screen. The resistance in series with the pressure circuit of the wattmeter is always such for any position of the photometer screen that the watts are cut down in inverse proportion to the candle-power, so that the wattmeter indicates watts per candle directly.

In a new room which has recently been assigned to photometric work, another photometer bench will be installed within the next few months. The plans for this bench, which will be constructed in the instrument shop of the Bureau, are being drawn up now, but sufficient progress has not been made to warrant any description at this time.

The small amount of life-testing which the Bureau has undertaken has been done on direct current, but a large alternating-current generator will be available within the next year, so that the capacity of the life rack may be increased from 200 lamps to 500 or 1,000.

In addition to the several complete photometer benches which have been described, there is much auxiliary apparatus which constitutes an important part of the equipment. A Brace spectro-photometer, with a special form of variable sector made by Franz Schmidt and Haensch, of Berlin, from designs by Professor Brodhun, is provided for studying the spectral distribution of light from radiant sources. Flicker photometers of both the Simmance-Abady and the Franz Schmidt and Haensch forms have also been secured.

As stated in an earlier paragraph, the sectored disc is one of the most convenient pieces of apparatus in the laboratory. The Bureau has a number of discs with fixed openings, and one or two with variable openings, but the principal difficulty with the discs of variable openings is that the range of angle is not sufficiently great. If each of the two discs forming the compound disc has a fixed opening of 180 degrees, the range of opening of the compound disc is from 180 degrees to 0 degree, but no angles greater than 180 degrees can be obtained. That is, the apparent intensity of the source when the disc is rotating is never greater than one-half the intensity when the disc is stationary. Now it is frequently desirable to get a gradual change in angular opening without cutting down the intensity as much as 50 per cent, *i. e.*, it is desirable to use angular openings between 180 degrees and 360 degrees. With the present form of variable sector composed of but two separate discs, if the maximum angle is increased, the minimum angle increases very rapidly, so that the angular range of the disc is cut down. Thus if the fixed opening of each disc is 300 degrees, the range of the compound disc is only from 300 degrees to 240 degrees. In order to obtain the desired large angle without sacrificing the small angles, it occurred to the writer to make a compound disc having two principal component discs with fixed openings of 300 degrees, and a number of very thin auxiliary discs whose only function would be to close the gap formed between the two principal discs when these are moved over one another in such a way as to reduce the angle between their calibrated edges. Between 300 degrees and 240 degrees this fan-like set of very thin discs does not come into play, but when the angle between the calibrated edges of the two principal discs is made less than 240 degrees, the discs no longer overlap, so that there is an opening between the other edges. This opening is covered by the auxiliary discs.

A disc of this kind has recently been made for the Bureau by W. and L. E. Gurley, who worked out the details of mechanical construction. Since the actual angular opening is only used to compute the ratio of transmission, we had this disc calibrated in per cent, which is much more convenient. It is also calibrated directly in candle-power, assuming the comparison lamp to be sixteen candle-power. The first disc made for the Bureau did not extend to 300 degrees, *i. e.*, eighty-three and one-third per cent, but only to about seventy-eight and one-half per cent. There is no particular difficulty in extending the range a little over 300 degrees if desired, but if the angle is made very much larger the number of auxiliary discs has to be increased greatly. At least one side of the disc should be blackened in order not to reflect light to the photometer screen.

The standard lamps of the Bureau constitute an important part of the equipment. These include five Hefner lamps, two Vernon-Harcourt ten-candle-power pentane lamps, one Carcel lamp, and a large number of incandescent lamp secondary and working standards. A comparative study of the various lamps that have been proposed as standards and are in use at present, is contemplated.

TESTING.

The work in photometry may be classified roughly under two general heads: testing and investigation. An important function of the Bureau is to verify standard lamps for lamp manufacturers or testing laboratories. The Bureau does not undertake at present to supply standard lamps, or to season new lamps for use as standards, but if seasoned lamps are submitted they are standarized at a nominal fee. The question is frequently asked, "What standard of candle-power is used at the Bureau?" Although the Bureau has adopted a definite unit of candle-power, which it maintains through incandescent lamp secondary standards, it has not as yet adopted a primary photometric standard. This fact should be emphasized, as it is sometimes stated erroneously that the Bureau has adopted the Hefner lamp as the standard. Neither the Hefner nor any other lamp has been or will be adopted as a primary standard until the various lamps that have been proposed as standards have been investigated thoroughly. What has been done has been to adopt a unit of candle-power which bears a certain ratio (100 : 88) to the Hefner unit as maintained at the Reichsanstalt. This seemed to be the best way of arriving at the English parliamentary candle, which was supposed to be the common unit of candle-power in the United States, both for gas and electric lamps. Inasmuch as the unit can probably be maintained constant through incandescent lamp secondary standards for an indefinite period, the adoption of a primary standard, though important, is not immediately urgent.

In addition to the testing of secondary or working standards, the Bureau undertakes to do a certain amount of commercial testing for various departments of the Government, and for private firms or individuals in cases of dispute, or where authoritative results are especially desired. It is prepared at all times to make special tests whenever these are practicable, to render assistance in the development of the proper methods of measuring luminous sources and illumination, and to aid as far as possible both the manufacturer and the consumer in drawing up suitable specifications for the purchase of lamps.

It has been seen that the present equipment of the Bureau is designed for the most part for the testing of electric incandescent lamps. Although no work has been done thus far on arc lamps, and little work on the photometry of gas and oils, it is hoped, in the course of time, to broaden the work so that there will be facilities for

measuring any kind of luminous sources. The photometry of incandescent lamps has been developed first, because there seemed to be more demand for it.

INVESTIGATION.

Not the least important part of the work is the investigation of problems in photometry. This includes the study of standards—primary, secondary and working, the development of accurate methods of photometric measurement, and the investigation of physical laws upon which the science of photometry depends. The scope of the work is therefore very broad, and the best results can be accomplished by maintaining a proper balance between investigation and testing. The one makes possible continual improvements in the other, and this in turn suggests fertile fields for further investigation.

The results of the investigations at the Bureau are published in the "Bulletin of the Bureau of Standards," and also at times, usually in abstract form, in some of the technical journals. Each paper printed in the Bulletin is published separately in the form of a reprint, which may be obtained upon application. A list of the papers published up to the present time, containing in a few words a statement of the nature or results of each investigation, is now in press. The following list of papers on photometry has been copied from this source, the numbers referring to the order of publication in the Bulletin:

PAPERS ON PHOTOMETRY.

No. 12. "On the Theory of the Matthews and the Russell-Léonard Photometers for the Measurement of Mean Spherical and Mean Hemispherical Intensities," E. P. Hyde. The accuracy of these instruments in measuring lamps with various simple polar distribution curves is investigated. The method is given for computing the best arrangement of any given number of mirrors to obtain relative values between lamps having different distribution curves.

No. 20. "The Use of White Walls in a Photometric Laboratory," E. P. Hyde. If proper black velvet screens are employed on a photometer bench the leakage of light into the photometer due to the diffuse reflection from white walls is shown to be so small as to be negligible.

No. 26. "Talbot's Law as Applied to the Rotating Sectored Disc," E. P. Hyde. The apparent intensity of a source, before which a sectored disc is rotating rapidly, is found to be proportional to the total angular opening of the sectored disc for all angles between 288 degrees and ten degrees.

No. 30. "An Efficiency Meter for Electric Incandescent Lamps," E. P. Hyde and H. B. Brooks. By means of a variable resistance in series with the pressure circuit of a wattmeter and controlled by the position of the photometer screen, the wattmeter is made to indicate watts per candle directly.

No. 43. "On the Determination of the Mean Horizontal Intensity of Incandescent Lamps by the Rotating Lamp Method," Edward P. Hyde and F. E. Cady. A study of the errors incident to this method, due (1) to the distortion of the filament on

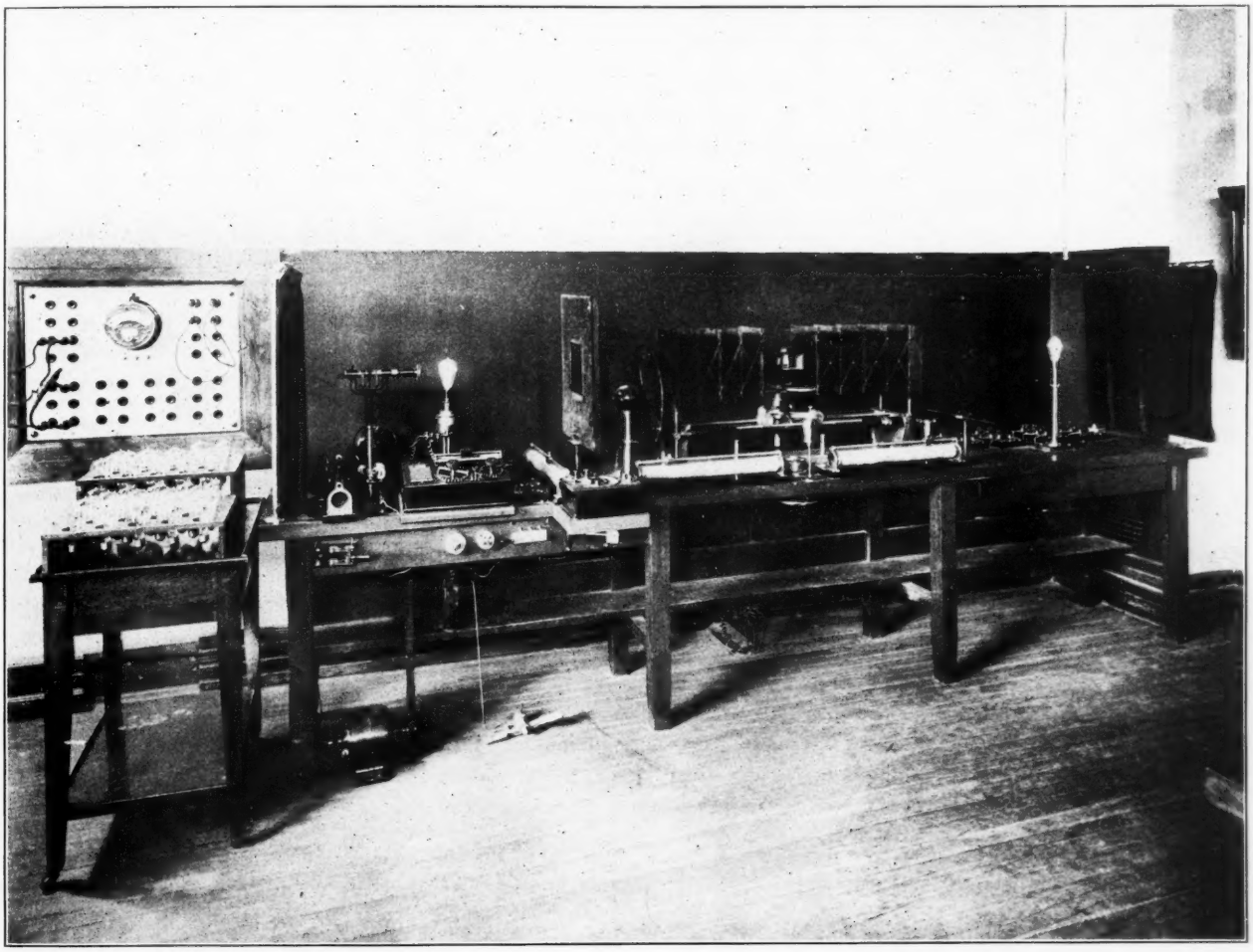


FIG. 5.—COMMERCIAL PHOTOMETER BENCH, NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

rotation, and (2) to the inability of the eye to estimate accurately a badly flickering illumination. By the use of a single stationary mirror accurate measurements of mean horizontal candle-power can be made, even with badly flickering lamps.

No. 50. "A Comparison of the Unit of Luminous Intensity of the United States with those of Germany, England and France," Edward P. Hyde. A number of seasoned incandescent lamps were carried abroad and measured in authoritative laboratories in the three countries named. The ratios of the units obtained through them are compared with the ratios generally accepted, and with those obtained in other recent investigations.

No. 51. "Geometrical Theory of Radiating Surfaces with Discussion of Light Tubes," Edward P. Hyde. Assuming Lambert's cosine law and the inverse square law to apply to infinitesimal surfaces, the errors incident to applying them to finite surfaces are deduced for several simple cases. From a consideration of the case of an infinitely long, uniformly bright strip of finite width a theory of light tubes is developed.

No. 61. "An explanation of the Short Life of Frosted Lamps," Edward P. Hyde. The rapid decrease in candle-power of frosted lamps is due, at least partly, to the increased absorption of the carbon film deposited on the inner side of the bulb. Owing to the diffuse reflection at the frosted surface, a relatively large part of the emitted light is compelled to traverse the absorbing carbon film three or more times before finally emerging. Results of confirmatory experiments are given.

No. 63. "On the Determination of the Mean Horizontal Intensity of Incandescent Lamps," Edward P. Hyde and F. E. Cady. A continuation of a previous investigation on this subject (see reprint No. 43). Other types of lamps are studied, and the methods and results of similar experiments by Uppenborn are discussed.

Some Artistic Requirements of Artificial Illumination.

By Bassett Jones, Jr.

"THE art of illumination" is a very apt phrase. The object of this paper is to accent somewhat broadly this aspect of the general problem of artificial illumination of architectural structures. The Illuminating Engineering Society has done much good work in clearing up our generally mixed and hazy notions as to the meaning of the various units used as a basis of measurement, and the value of the many types of light sources considered from the standpoint of color, life, and energy-efficiency. There has been, however, decidedly little study of the architectural features of the various illuminants and their adaptability to any particular scheme of interior arrangement; and it further appears that the subject of efficiency has been greatly exaggerated.

The energy-efficiency of the light source is, of course, a very important item in the consideration of any lighting scheme, but this in its turn must eventually be controlled by the higher term of efficiency of the scheme as a whole. The ratio of output to input does not cease to be a factor at any assumed standard distance from the lamp centre. Its value is eventually determined by purely psychological considerations—by the mental effect which the usable light has upon the beholder. By this I mean, that if an interior designed to give certain harmonies of color or form under normal daylight as to direction and diffusion, is distorted or over-emphasized in any respect by any given type of interior illuminant, then the actual watt-efficiency of that particular light source can have very little, if any, weight in determining its suitability for the particular case.

On the other hand it is perfectly possible, and often desirable, to make the effects due to artificial illumination differ decidedly from the effects obtained by daylight, and this gives rise to a problem far more difficult of solution than one where artificial illumination only is to be used. The interior architectural and color arrangements will rarely admit of any careless handling of shadows and color of impinging light. The problem then becomes one that can only be successfully treated through thorough sympathy with the aesthetic features of the case.

The primary difficulty is that the directness and added diffusion of general interior lighting tend to unduly accent the less important elements in the design with a corresponding diminution of the prominence of the salient architectural features. The result is an apparent flatness and loss of interest. Such an interior, while lighted with due consideration of the proper distribution and intensity of light from a purely engineering standpoint, may still be excessively trying directly to the eyes, and, indirectly through the nervous system, by the lack of prominent features that arrest the attention. This is sometimes the case in large halls and auditoriums where the general simplicity of the design is still more simplified by undue diffusion of the interior illumination. The result is quite as injurious and productive of optical strain as too little or too much light and badly placed light sources.

A knowledge merely of inverse square laws, polar diagrams, coefficients of reflection, and efficiency of light sources is a pretty poor equipment wherewith to attack a problem in which aesthetic values are of any moment. The subject should be approached rather from the standpoint of the effects to be obtained than from the standpoint of the lamp. The problem is not what effects will result from any empirical arrangement of a certain type of lamp, but what arrangement is necessary to produce certain pre-established effects. And these effects must be pleasing and restful to the eye, otherwise they can not possibly be artistic.

It would be an exaggeration to liken the engineer of illumination to an engineer of decoration, but the terms serve to illustrate the point that I wish to make. The decorator or architect must have a thorough, exact knowledge of his materials and their uses in his art, but this is a very different thing from the results he gets by an application of his knowledge. His design embodies his feeling for harmony in color and proportion under the conditions set by the problem. The conception of the design is not governed by established scientific generalities. Science is called upon to show in what way the idea may best be embodied, and it goes without saying, that if the design is correct, it will readily lend itself to actual construction.

The data upon which the illuminating engineer is to base his calculations can not be obtained merely by scaling up the area to be lighted and by assuming a general shade for surface color. Formulas are meaningless unless they result in practical solutions. Except under very special conditions illumination is not a matter of lighting plane surfaces, but rather is its object that of making pleasing and restful a decorated structure.

The primary considerations that must govern the design of an architectural lighting scheme are:

(1) The general form of the structure to be illuminated—is it massive or slender? Does it require the use of shadows, and to what extent, in order to set in relief the principal features? Do the structural members—columns, pilasters, soffits, arch members, etc.—require accenting?

(2) The relation of the decoration to the structural lines. In good design, where the structural lines form the chief beauty of the structure, and where proper care has been taken under (1) to accent these lines, usually the decoration will be sufficiently pronounced. If, however, decoration is used, as it often is, to cover up a paucity of conception, it is sometimes necessary to accent the decoration in lieu of the structural motif; otherwise a feeling of unbalance may result. Or the very reverse of this treatment may be necessary. As an instance of the use of these two foundamentals of illuminating engineering, I will take as an illustration a certain auditorium lighted during the day by windows behind the audience and by a huge stained-glass skylight in the ceiling. This skylight is necessarily of primary importance in the architectural scheme, and its size requires rather broad dividing mullions and molded borders, all of which are heavily decorated, which is bad, as the headroom is not sufficient to remove the appearance of undue weight. To give a feeling of stability the mullion lines are carried down the arched ceiling by false beam soffits, which in turn rest upon a wide molding carried around the walls. The wall is so paneled that the soffit lines are carried down to the base board without any actual pilasters. This arrangement of arched ceiling and heavy molding provided an excellent opportunity for the use of cove lighting, with a resulting softness and diffusion of artificial light, which, from a purely engineering standpoint, is well carried out. But the unfortunate feature of the scheme is that the great diffusion produces such an absence of shadows that the false beam soffits are flattened out and the heavy ceiling brought still lower in appearance, resulting in a sense of structural weakness. The attention of the audience is distracted by the feeling that the ceiling is about to fall and an effect is produced quite as trying as would be caused by an excessive intrinsic brilliancy in the illumination. A much better effect, with greater economy, could have been produced by the use of lights above the skylight to give it an appearance of semi-transparency, thus increasing instead of reducing the apparent headroom, and by accenting the points of support where the beam soffits joined the skylight molding by the use of short-stemmed fixtures. The space between the soffits could be deepened by tinting, and the structural lines on the walls accented by the use of well-shaded wall fixtures.

The positions of columns used to support a gallery or a roof, particularly in churches, require to be accented at night, otherwise the illumination in the aisles may carry the eye beyond the columns, its natural resting place, to the walls behind.

A further point under this heading is perspective. Interior lighting, unless designed with great care, will often entirely destroy the perspective effect of parts of the structure lying at any distance from the eye. For this reason parallel rows of lights arranged vertically are to be avoided. Great brilliancy of interior illumination also tends to reduce the perspective, as the eye becomes less sensitive to changes in brilliancy at high intensities. Further, as the lights recede, they are brought more into the field of vision and so receive a false accent, due to their claim upon the attention.

The point always to be remembered is that the interest in a building or interior generally, lies in its structural lines and points of support. They are its principal features and require to be brought into prominence.

I do not mean that the actual usable light need come from these points. They are merely to serve as means of arresting the attention by supplying somewhat more than the general quantity of illumination over limited areas. While not always economical from a mathematical standpoint, such light sources are often decidedly economical from a psychological standpoint, which, as I have already pointed out, is really the determining factor in artistic illumination.

(3) The consideration next in importance is the color scheme. A pleasing effect of change may sometimes be produced by the alteration in tone due to the difference between the reflected daylight and artificial illumination. But this is a matter requiring careful judgment and certain foreknowledge of the results. It must be remembered that it is not bright white light, but rather a broadly diffused light of a grey or greenish tone that filters through the window panes during the day, and that when the sun is low enough to shine directly into the interior it gives light of a yellow or orange tone. Very rarely is it possible to depart from these colors in artificial illumination without producing startling and staring effects. The field for contrast lies rather in the difference in direction and diffusion of light, and this may be achieved in a multitude of ways provided the considerations pointed out in (1) and (2) are taken into account.

Great brilliancy is rarely pleasing and often injurious to the eye. As is well known, the eye can not properly discriminate details or contrasts under the strain due to excessive illumination, which, as has already been pointed out, produces an apparent flatness in the architectural design. From an artistic standpoint, and very probably ultimately from a physiological standpoint, the brilliancy of interior illumination should be kept as low as is compatible with comfort and safety. There is no evidence that the insatiable craze for excessive lighting that has made its appearance in this country is conducive to any beneficial results. The argument that since the eye is subjected to the great brilliancy of sunlight without excessive strain, a similar brilliancy may be approached safely by artificial means, does not take into account the great difference in quality between the two conditions.

Of course, any color used in decoration may be made excessively trying by improper or excessive illumination; but certain colors, such as high reds, blues, or purples, are inherently injurious, and where they are used extensively it is practically impossible to secure general illumination that will be sufficiently intense for ordinary use without producing optical fatigue if the eye is subjected to its influence for any considerable period. Under such conditions the color value of the illuminant must be suitably adjusted to tone down any disagreeable vividness. Decorative color used in this way is generally absurd from an artistic standpoint, and is rarely encountered except where bad taste has governed the design. In any case where such conditions are to be met, it is desirable to leave the colored surfaces in comparative darkness, as they naturally will be during the daytime, since their low coefficient of reflection will conduce to deep shadows.

The usual and most natural general decorative colors are greys, browns, greens, yellows, soft orange or white, and may go with considerable brilliancy of illumination, which will, of course, be more or less

modified by the diffusing and reflecting qualities of the surfaces. White and light-colored surfaces require somewhat careful treatment if the natural cheerfulness of the interior is not to be overemphasized. The illumination of a light-tinted room of any architectural pretensions is normally much diffused, and shadows will play an important part in the general effect. These shadows must not be obliterated by artificial illumination.

These several conditions determined, it then remains for the engineer to cast about for a type of illuminant provided with suitable globes, reflectors, etc., that will meet the conditions of the problem most economically, and that will at the same time be suitable for use in a fixture that will harmonize with the decorative and architectural features of the scheme. In the first place, the essential idea at the basis of every architectural design is founded in a structural purpose. The line of static force, carried out by the column and the arch line, is the primary motive, and the aesthetic worth of the design depends upon securing a proportion between the members that will produce a sense of stability and equilibrium. The column, arch, or suspension that is not used as a visible means of support for a superimposed structure is about as bad from an aesthetic standpoint as is possible, and it is interesting to note that a supporting member properly proportioned for the work it has to do is naturally suitable for good architectural treatment. Decoration is used never as a means of support in itself, but merely to accent the principal structural features without concealing or disguising them.

A lighting fixture is quite as amenable to these canons of architecture as is a massive cathedral. The fixture is used to support lamps with their attendant shades and reflectors, and this should be the most evident thing about it. The lamps themselves usually being insignificant when not lighted, it is important to accent the holders by means of ornament, and where the fixture is necessarily simple, but little decoration should be used at any other point. The matter of proportion between the several members is, of course, of primary importance.

These are considerations that rarely receive sufficient attention. Lighting fixtures are usually treated as minor items in the design and often go far toward ruining an otherwise pleasing work. But the fact remains that if the purpose of the device is constantly held in view, no proper engineering requirements will make any demands upon it that can not be met in a suitable manner.

This article does not pretend to encroach upon the purely scientific side of illumination. It merely attempts to indicate where the illuminating engineer must look for his problem. He has no *à priori* solution. His business is to meet the conditions at hand and to devise a scheme of illumination that will do much more than supply so many candle-feet over a given area. Here lies the chief difficulty of his profession.

Photometric Units.

By Preston S. Millar.

REVIVED and newly aroused interest in photometry has been occasioned by a belated recognition of its important bearing upon artificial lighting. Recent notable strides taken by illuminating engineering as a legitimate specialty have led to considerable discussion of the photometry of single light sources, and of total illumination. Such discussion has brought to the surface the existing confusion in photometric units and nomenclature. The Illuminating Engineering Society has been prompt to recognize these difficulties, and to take appropriate action in the appointment of an International Committee on Nomenclature and Standards, which committee is authorized to cooperate with other representative bodies.

Much of the confusion as to terms used in photometry has been occasioned by the application of names adopted in connection with a given system of units to similar quantities based upon an entirely different system of units; for example, the name applied to the unit of illumination intensity in France, has been applied in Germany to a unit of illumination intensity based upon a different unit of luminous intensity. In the two countries, therefore, the lux designates values which

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differ to such a degree as to occasion considerable confusion.

Much of the nomenclature used in photometry in the United States of America is derived from a system of units adopted at the International Congress of Electricians, held at Geneva in 1896. At this conference a paper was presented by Professor Andre Blondel, proposing a system of photometric units. This paper was referred to a committee of such eminent men as von Alteneck, Arno, Hospitalier, Janet, Kapp, Palaz, Rey and Rosseau. The report of this committee, which was adopted by the congress, recommended the system of units proposed in Blondel's paper, with only slight changes. The system of units and the definitions which were given, follow:

Standard of	Name of Unit.	Symbols and Equations.
Luminous Intensity	Bougie (candle)	I
Luminous Flux.	Lumen	$\Phi = I\,\Omega$
Illumination Intensity	Lux $= \frac{\text{Lumen}}{\text{Sq. M.}}$	$E = \frac{\Phi}{S}$
Brightness	Bougie per Sq. Metre	$e = \frac{I}{S}$
Quantity of Light	Lumen-hour	$Q = \Phi\,T$

DEFINITIONS.

Unit of Luminous Intensity—Bougie. The luminous intensity of a source formed by five square millimetres of incandescent platinum, at the temperature of solidification, measured at a relatively great distance along a line normal to the surface of the platinum. This is intended to equal one-twentieth of the Violle standard.

Unit of Illumination Intensity—Lux. The illumination intensity produced by a punctiform source, of luminous intensity equal to one bougie, on a normal surface one metre distant.

Unit of Flux—Lumen. The flux received by a surface of one square metre

having uniform illumination intensity of one lux.

Unit of Quantity of Light—Lumen-hour. The product of unit flux by unit time.

Unit of Intrinsic Brightness—Bougie per square metre. The brightness of a surface of unit intensity per unit surface.

The units as adopted by this congress, and as listed above, have only such international significance as their merit may invest them with; for English and American engineering bodies were not authoritatively represented in the discussion of these units, and German delegates forming a minority may or may not have endorsed the system. The adoption of the report is said to have been far from unanimous, and only after a spirited discussion of some of the points involved.

Respecting a standard light source, it may be said that the International Congress of Electricians in 1884 adopted Violle's platinum standard. The International Congress of Electricians in 1889 adopted as a unit of luminous intensity one-twentieth of the Violle platinum standard, designating this unit as the bougie decimale (decimal candle).

Blondel, in his paper before the 1896 congress noted objections to the Violle platinum standard, because of practical difficulties in its use. This had resulted in the practice of deriving the bougie decimale from the Carcel lamp, which the determinations of Violle had shown to be equal to 9.68 bougie decimale. In practice, therefore, the Carcel lamp had become the primary standard light source in France. In England, the spermaceti candle was fast being displaced by the Vernon-Harcourt ten candle-power pentane standard. In Germany, the Vereinkerze had been practically supplanted by the Hefner-von Alteneck amyl-acetate lamp, which had become the legal standard of light in that country. Blondel considered that these three lamps constituted the only primary standard light sources with which one had to deal in practice. All were liable to variations and practical difficulties, which necessitated careful and expert manipulation. The Hefner lamp was perhaps more reliable and satisfactory than the Carcel or Harcourt lamp. The photometric unit being in reality a physical quantity with a physiological coefficient, must be empirical; therefore, there could be no serious objection to the adoption of a suitable abitrary unit of luminous intensity, such as that proposed above, in the absence of a fundamental unit which could be accepted internationally.

In the paper discussing these units, much stress was laid upon the possibility of differences between the "visual acuity" and "equal brightness" methods of determining luminous intensity. It was suggested that in important comparisons of light sources, particularly those sources in which the more refrangible rays predominate, results obtained by both methods should be stated.

The report of the committee, as adopted by the congress, included a suggestion that, as the bougie unit of luminous intensity differed from the Hefner unit by only from two to six per cent, the two might be used interchangeably for many purposes. [1]More recent determinations indicate this difference to be in the neighborhood of eleven per cent, so that this loose statement as to the relation between these two units has occasioned much confusion, as a result of which we find the lux, the unit of illumination intensity, used in connection with the Hefner, in Germany, and in connection with the bougie in France. There is, perhaps, no one unit which has been so variously defined as the lux. If one searches far enough he can find some more or less authoritative definitions of the lux based upon every unit of luminous intensity that has ever been recognized. It has even been defined as the illumination produced upon a normal surface at a distance of one meter by a Carcel. It is well to bear in mind that this unit, as proposed and adopted at the 1896 congress, at Geneva, was based upon the bougie as a unit of luminous intensity.

Blondel laid emphasis upon the possibilities of usefulness of the unit of light flux, the lumen. Many difficulties were experienced, because of the rating of illuminants by intensity in a single direction, or in a single zone, the general result of which was an over-rating of artificial light sources. It was out of the question to persuade electric lighting interests to rate lamps in terms of mean spherical intensity, which, from the academic standpoint, was the logical basis of rating. The adoption of the lumen as a unit of light flux, offered the possibility of rating lamps by their total luminous flux, which would mean, for ordinary incandescent lamps rated at sixteen candle-power horizontally, about 160 lumens. There could be less commercial objection to a change of this character than to a change which would involve the rating of lamps by means of the mean spherical intensity, giving them a lower commercial value in the scale of units adopted than that at present in vogue.

More recently, the advantages to be obtained from a consideration of light flux have been appreciated in the United States, not only in connection with luminous intensity, but also in various conceptions of illuminating efficiency. As the lumen may also be defined as the flux of light produced in a steradian, or unit solid angle, by a uniform source of one unit luminous intensity, this term may happily be considered to be independent of the units employed in linear measure. Therefore one lumen will produce one lux upon a plane normal surface of one square metre at a distance of one meter. It will produce one foot-candle upon a plane normal surface of one square foot, at a distance of one foot. This unit seems to be destined for a field of great usefulness, in lighting practice in the United States.

The system of photometric units, as adopted at the Geneva congress, is important, since it is used largely in present practice, and constitutes a point of departure for other proposed systems. Thus, the recent recommendations of the Standardization Committee of the American Institute of Electrical Engineers are built up largely on the system under discussion. These recommendations appear in Appendix C, of the report presented before the 1907 convention of the American Institute of Electrical Engineers, and later approved by the board of directors of that society. The candle-power, defined as 1.13 Hefners, is the unit of luminous intensity; the candle-lumen, the unit of flux, and the candle-metre, the unit of illumination intensity, with the candle-foot as an alternate.

In this proposed system of units, it is difficult to see why the unit of illumination intensity has been called the candle-metre, since all of the objections which have been raised against the candle-foot as a name apply with equal force against the term candle-metre. The candle-lux would appear to be a better term than the candle-metre, in that it would conform more closely to the excellent system of units adopted at the Geneva congress, being modified only by the word "candle" as was done with the lumen. Until we shall be able to avail ourselves of the many advantages of the metric system, the candle-foot or preferably the foot-candle, could be used as a practical working unit, while the candle-lux would be available when the metric system is adopted in the United States. The nearest approach to international standardization of photomet-

[1] At conference of the International Committee on Photometry, at Zurich, July, 1907, the following relations between primary standard lamps were reported:
Carcel = 10.75 Hefners.
Harcourt = 10.95 Hefners.
Harcourt = 1.02 Carcel

ric nomenclature that seems feasible, pending the adoption of an international standard of light and system of linear measure, is the use of fundamental units proposed by the Geneva congress, with the addition of a prefix to indicate the unit of luminous intensity upon which they are based.

The Nernst Glower and the Present Status of the Nernst Lamp.

By Otto Foell.

WHEN the Nernst system of illumination entered the American field as a competitor of the arc and incandescent system, its application was limited in contrast to foreign practice to alternating-current circuits. A standard type of Nernst lamp was developed which met all requirements of ordinary illumination. Owing to its increased efficiency, which meant a reduction in current bills, it soon came to be regarded as the lamp which brought electric light within the means of everybody.

The flexibility of the Nernst system was soon recognized as one of its best features, and units varying in illuminating intensity were readily obtained, while the quality of the light remained unchanged.

To-day, the commercial development of the Nernst lamp through its many possibilities of operating the glower, covers practically every field of commercial lighting.

At the convention of the National Electric Light Association, held in June, 1907, at Washington, D. C., the announcement was made of the successful development of the direct-current Nernst lamps in America; the development of a new 110-watt higher-efficiency unit; and the development of new types of ceiling lamps, adapted for use in artistic bowl fixtures. Prior to that, the Nernst series system had been successfully worked out, and its superiority for street lighting has been demonstrated in a number of installations in different parts of the country.

Before I describe the details of the different new applications of the Nernst glower, I want to mention some of the lamp characteristics, such as the glower and ballast. I shall endeavor to describe some of the features pertaining to the glower, in connection with a few facts bearing on the direct-current glower, and the glower used in the higher-efficiency 110-watt lamp.

GLOWER.

The light-giving element of the Nernst lamp is termed the "glower." It is a non-conductor of electricity when cold, but becomes a good conductor when heated sufficiently to permit the passage of a current, thereby bringing it to bright incandescence.

MR. OTTO FOELL, CHIEF ENGINEER, NERNST LAMP COMPANY.

Broadly speaking, a glower may be any substance or combination of substances fulfilling the above requirements, yet the application of the glower principle is limited to materials possessing the qualities of practical lamp performance. In other words, the glower life must be sufficiently long to insure a reasonable maintenance cost, and the electrical and

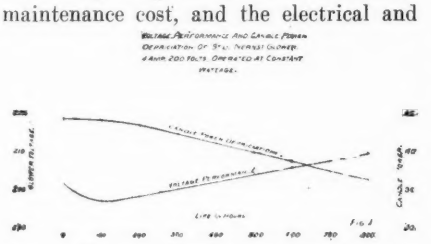


FIG. 1.—VOLTAGE PERFORMANCE OF STANDARD NERNST GLOWER.

physical characteristics must be such as to be within proper limits, *i. e.*, the temperature to which a glower is subjected must produce an efficient light and the starting of a glower must be accomplished by means of a heater easily produced and maintained with a reasonable outlay of money.

After an exhaustive series of tests in which almost every possible combination of oxides had been tried, it was found that a combination of zirconium and yttrium oxides gave results closely approaching commercial requirements. Yet, before their manufacture could be undertaken a number of problems presented themselves, such as influence of impurities on electrical performance and surface depreciation; the application of terminals; the effect of different mixtures on the current voltage characteristic and light efficiency; the effect of efficiency on the glower life; the effect of the physical characteristics of the glower material on the electrical performance, etc.

The presence of impurities in the glower is responsible for rapid changes in its resistance during operation. Certain substances are instrumental in raising the resistance of the glower, resulting in an increased watt consumption when operated at constant current, and causing, among other effects, crystallization, and eventually, the formation of new chemical combinations.

It is evident that in commercial glowers, impurities should be avoided, or, at least, their effect be minimized and counterbalanced as much as possible.

Fig. 1 shows the voltage performance of a standard Nernst glower, Piece Number 391, during its life, operated at constant wattage, and the corresponding candle-power depreciation, while Table I contains the figures used in plotting the curve:

TABLE I.

LIFE PERFORMANCE OF A GLOWER AT CONSTANT WATTAGE.

Life.	Voltage.	Per Cent Increase.	Candle-Power.	Per Cent Depreciation.
0	202.0	0.00	44.5	0.0
25	200.0	—1.00	44.3	0.5
100	197.2	—2.38	44.0	1.1
200	199.0	—1.49	43.6	2.2
300	200.8	—0.60	42.5	4.5
400	202.6	0.30	41.4	7.0
500	204.3	1.14	40.0	10.0
600	206.3	2.13	38.9	12.6
700	208.0	2.97	37.6	15.5
800	210.0	3.96	36.5	18.0

The application of terminals presented some difficulties inasmuch as the terminals should be strong, mechanically, and perfect, electrically. The solution offered by Dr. Nernst was to wrap strands of fine platinum wire around the glower string and to coat the platinum with ground glower material.

The terminal as applied to the standard alternating-current glower of American

make consists of a bead of platinum fused into the end of the glower material.

Each terminal has its merits according to the use it is subjected to; for instance, the "Hanks terminal," as the standard alternating-current glower terminal has been called, is, without modifications, entirely inadequate for service on direct current. A modification of the Nernst terminal is the so-called band terminal consisting of a ribbon of platinum pressed around the glower string and fused together at the free ends. The terminal is coated in the same way as the regular Nernst terminal and possesses the advantage that the platinum adheres to the glower string as readily as the bead does.

As will be understood from the very nature of the glower, the resistance decreases with increasing temperature. The decrease in resistance, however, is not constant, and this fact explains the shape of the current-voltage characteristic. Referring to Fig. 2, which shows the relation between current and voltage of a standard 0.4-ampere glower, a minimum in glower voltage is noticed occurring at 0.16 ampere. Before this point of the glower characteristic is reached, heat must be applied from the outside, as the energy expended internally does not supply sufficient heat to maintain the glower as an electric current conductor. After passing the 0.16-ampere point a rapid rise in glower voltage takes place. The voltage soon reaches a maximum and would rapidly drop to zero if current were allowed to flow unchecked. An inspection of the curve referred to shows that the normal point at which the glower is operated is near the maximum voltage of the current-

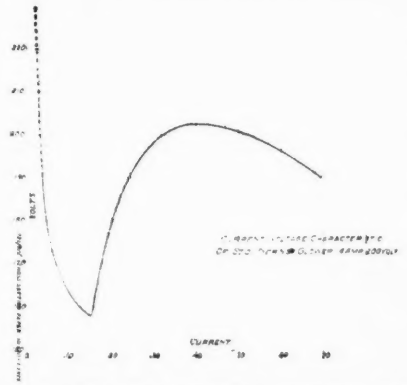


FIG. 2.—RELATION BETWEEN CURRENT AND VOLTAGE OF 0.4-AMPERE NERNST GLOWER.

voltage characteristic. The operation of a glower, beyond the knee, is unstable and unsafe.

The shape of the characteristic changes with the proportion of the elements used in the construction of the glower, *i. e.*, glowers of different mixture will reach the bend of the characteristic at different efficiencies. Other influences determine the current-voltage characteristic, such as the diameter of the glower. In a large glower the heat in the centre is so much greater that the material may be near the melting point, while the surface remains rather cool. This effect has been overcome by making the glowers for higher current-carrying capacity in the form of a tube string, thereby removing the inside of the glower. Of course, it is natural that such a string must be very uniform in wall-thickness and density; otherwise, an undue heating will take place at or near the point of decreased density, resulting in an early failure of the glower.

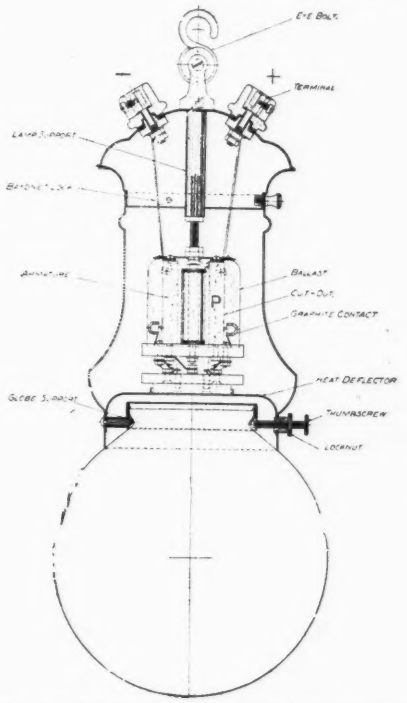


FIG 3.—VERTICAL SECTION THROUGH THREE-GLOWER NERNST LAMP.

The higher-efficiency glower as used in the 110-watt lamp is a tube string as described above, and its proportions are somewhat different from the standard alternating-current glower.

The effect of efficiency on glower life is the same as on an incandescent-filament lamp running at increased current rating. However, the effect of higher operating temperature may be counterbalanced by proper operating conditions of the auxiliary parts of the lamp, and also by changing the mixture of the constituent parts of the glower. On the new higher-efficiency alternating-current unit, a glower life of 800 hours at an increased efficiency of fifteen per cent is obtained at a candle-power depreciation of about twenty per cent. On direct-current circuits the corresponding life is 500 hours.

As stated above, impurities contained in the glower material change its electrical resistance; however, the physical characteristics of the material selected for making glowers have a great bearing on their electrical qualities resulting in either a rather porous glower or a very well vitrified and strong glower for rough usage. In America we aim at getting a glower of the latter description which will take readily to the Hanks terminal and is particularly adapted for use on alternating-current circuits.

Unlike the alternating-current glower, the direct-current glower should be as porous as possible, the idea being to help along the electrolytic effect, whereby oxygen is the negative ion and either atmospheric oxygen or oxygen dissolved and diffused in the glower is the depolarizer. Oxygen must, therefore, reach and react with the reduced metal at one electrode and anodic oxygen liberated must escape. Now, a well-vitrified surface hinders, or at least, retards this flow of oxygen. For the same reasons, the terminal construction of a direct-current glower is different from that of the standard alternating-current glower. In the direct-current glower, as manufactured by the Nernst Lamp Company, this idea is incorporated by making the negative terminal a band terminal, as described above, and the positive terminal a Hanks terminal, coated with ground glower material, the purpose of the coating being to increase the radiating surface of the glower terminal, thus taking care of the large amount of heat liberated at this terminal due to what is known as the Peltier effect. This effect

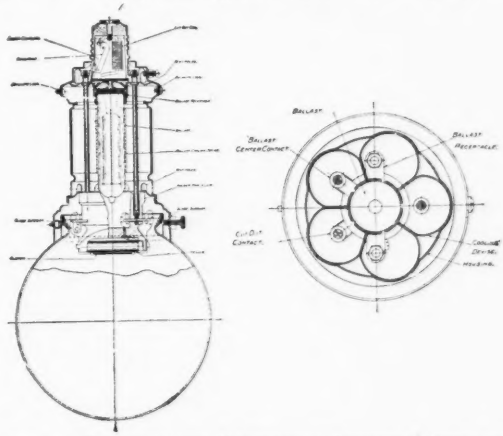


FIG. 4.—VERTICAL AND HORIZONTAL SECTIONS THROUGH 110-WATT, HIGH-EFFICIENCY NERNST LAMP.

also is responsible for the fact that a direct-current glower is so much cooler at the negative terminal—heat being absorbed while the current is flowing from the glower material to the platinum.

BALLAST.

The peculiar current-voltage characteristic of the Nernst glower, as shown in Fig. 2, makes the employment of a steadying resistance necessary. Much study has been given to this question, and finally, a resistance was employed consisting of a very fine iron wire operated at a temperature of almost recalescence, the wire being properly supported and mounted in a glass container filled with hydrogen; this resistance is termed the "ballast."

On a ballast, as described above, a slight increase in temperature is accompanied by a very large increase in resistance, so that with increasing voltage the current increases only a very small amount.

A study of the ballast would be incomplete without considering its sluggishness; by sluggishness being understood the time necessary for the ballast to adapt itself to various conditions. The very nature of the ballast depending upon an increase in temperature for current control is in itself a cause for sluggishness, *i. e.*, a momentary increase or decrease in watt input can not be taken care of momentarily on account of the heat capacity of the materials used in the construction of the ballast. The surrounding medium influences the characteristic of a ballast, tending to decrease its current capacity when placed in a medium such as a housing. It has been found that sluggishness may be eliminated by operating a ballast in water, which, however, is hardly possible for application in a lamp. The higher-efficiency 110-watt lamp uses a metallic cooler, which reduces the effect of ballast sluggishness in a large measure.

FIG. 5.—110-WATT HIGHER-EFFICIENCY NERNST LAMP WITH HOLOPHANE REFLECTOR.

NEW APPLICATIONS OF NERNST LAMPS—NERNST LAMPS FOR DIRECT-CURRENT CIRCUITS.

Until recently, only isolated cases of the application of Nernst lamps in America for direct-current circuits have been heard of; one of these being an installation in the establishment of Sears, Roebuck & Company, of Chicago, where 4,250 single-glower Nernst units have been operated for about eighteen months, obtaining an average life of about 900 hours per glower. Some direct-current glowers were sent to the National Bureau of Standards, where they were used for investigating the sectored disc in photometry, and in a study of the law of inverse squares.

Fig. 3 represents a cut in vertical direction through a three-glower, direct-current lamp, showing the arrangement of the working part inside the lamp housing.

At the present writing, Nernst lamps for direct-current circuits are being sold in the one, two and three-glower types. Experiments are being conducted to bring upon the market the four and six-glower types as well. While the latter types of lamps show excellent results of operation both in glower life and candle-power performance, they are not sufficiently developed as yet to be brought upon the market for general use. On direct-current circuits a glower life of 500 hours is guaranteed. As stated before, in the case of Sears, Roebuck & Company, of Chicago, an average life of 900 hours per glower is being obtained, exceeding this guarantee by 400 hours, and I feel sure that in many instances equally as good results will be obtained, provided the lamps receive the proper care and maintenance.

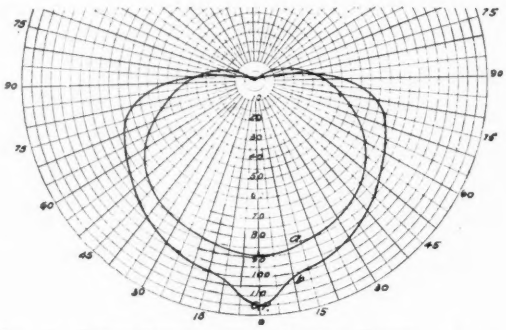


FIG. 6.—LIGHT-DISTRIBUTION CURVES GIVEN BY 110-WATT, HIGHER-EFFICIENCY NERNST LAMP.

NEW 110-WATT HIGHER-EFFICIENCY UNITS.

The 110-watt higher-efficiency Nernst lamp has been developed to meet a demand for a screw-base lamp for use where ordinary single-glower lamps would be too small to give the desired illuminative effects, and at the same time it was aimed to obtain a unit which has the same efficiency as the standard multiple glower type of lamps. Fig. 4 shows two sections through the lamp; one in the vertical and the other in the horizontal direction. Referring to the illustrations, it will be noted that the lamp is built to screw into an Edison screw base. The elements of the lamp, such as ballast, cutout and holder, have been arranged in such a way that they can be easily reached by the loosening of a few screws. The cutout, which works on the gravity principle, is located in the lamp base proper. On top of the lamp base is mounted a brass shell with bayonet slots, into which a ballast equipped with base may be inserted. The ballast is enclosed by a copper spring by means of which the heat liberated in the resistance wire is transmitted to the lamp housing, thereby increasing the radiating surface of the ballast, which results in the effect as described earlier in the article. From the lamp base project three prongs through the lamp housing to the lower part of the lamp, into which a holder may be inserted, the latter receiving the heaters and glower. The base of the lamp housing is provided with pin and screw-catch to receive either a four or five-inch globe. The outside of the lamp base is formed in such a way that a shade-holder may be attached by means of pin and bayonet catches. The general appearance of the lamp is shown in Fig. 5. In the illustration the lamp is shown using a Holophane shade, catalogue No. 3610.

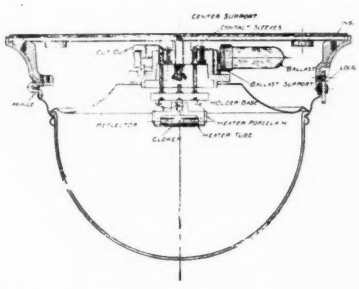


FIG. 7.—SECTION THROUGH THREE-GLOWER BOWL NERNST LAMP.

As regards light efficiency, the lamp is a decided improvement over the old eighty-eight-watt unit. Light distribution curves taken by the Electrical Testing Laboratories are reproduced in Fig. 6. A comparison of efficiency between the 110 and

the eighty-eight-watt units is given in the accompanying table:

TABLE II.[1]

	110-Watt Unit.	88-Watt Unit.
Wattage	109.00	88.00
Mean Hemispherical C.-P..	79.4	40.2
" " Efficiency.	1.37	2.19

The candle-power of the lamp in the direction of maximum intensity when using a clear ball is 115, thereby giving an efficiency of 0.96 watt per candle-power without the aid of reflectors.

NERNST LAMPS FOR USE IN BOWL FIXTURES.

As stated in the introductory remarks, a lamp had been developed which met the requirements of ordinary illumination, yet the appearance of the lamp hindered in many cases its general acceptance where the architect or decorator desired a decorative effect. The result of the desire to get artistic effect was, first, a lamp called the "Canopy" lamp. Such a lamp had the top spread out and the lower part of the lamp was designed in keeping with the upper part, yet many instances were met where such a type of lamp did not suit the taste of the decorator. To meet the requirements of almost every line of fixtures, a lamp has been designed which may be mounted in artistic ceiling bowls, thereby combining elegance and efficiency.

Fig. 7 shows a section through a three-glower bowl fixture, and Fig. 8 gives an illustration of the appearance of the lamp as manufactured as standard by the Nernst Lamp Company. However, the lamp body may be mounted into any fixture desired, its decreased height adapting itself particularly to such work and thereby giving the fixture an efficiency not heard of heretofore. As will be noted in Fig. 7, the ballasts are arranged around a porcelain base in a horizontal direction. This porcelain also receives the cutouts for operating the heater circuit, the binding posts for connecting the line to the lamp and aluminum sleeves into which the holder is inserted. The whole lamp body is held to the fixture by means of a square centre post and thumb-nut, thereby making its installation and removal an easy matter. A feature of the lamp is the metallic reflector placed above the glower, which not only reflects light thrown into the upper hemisphere in a useful direction, but also cuts off the heat of the glower successfully from the upper part of the lamp body.

To obtain artistic effects, either art bowls or Holophane hemispheres may be used.

This new adaption applies to Nernst units of all sizes and will permit of uniformity in design and illumination value throughout a complete installation.

NERNST SERIES SYSTEM FOR STREET LIGHTING.

Ever since the introduction of the Welsbach system for street lighting, a demand has existed among electric lighting interests for a more efficient unit having a lower maintenance cost than the ordinary incandescent lamp. To meet this require-

FIG. 8.—BOWL FIXTURE, THREE-GLOWER NERNST LAMP.

ment, a system was designed whereby it is possible to operate Nernst lamps successfully on any existing alternating-current arc circuit.

A Nernst series lamp outfit consists of a transformer, which supplies the energy to the lamp terminals, a lamp with proper holder, globe and reflector.

Recognizing the fact that a proper street lamp must throw the light in an angle a few degrees below the horizontal, a vertical glower has been employed which not only meets the requirements better

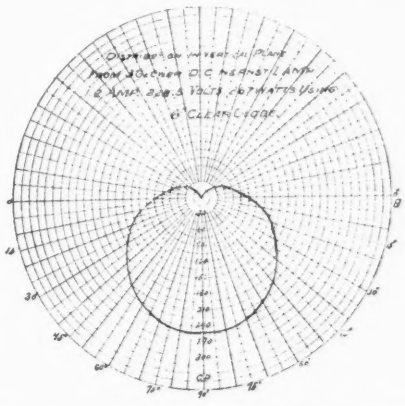


FIG. 9.—LIGHT DISTRIBUTION FROM THREE-GLOWER STREET SERIES NERNST LAMP.

than any other known illuminant, but also allows easy renewal when the lamp needs attention. The light distribution obtained from a series unit is shown in Fig. 9.

The feature of the system is the transformer; unlike the transformer for operating in parallel from alternating-current mains, the series transformer is operated from a constant-current line, thereby giving a constant primary magnetic flux, which is counterbalanced by the current of the lamp. Normally the current-voltage characteristic on the secondary side would be very unfavorable, so the transformer had to be designed to give such a characteristic as would permit the safe operation of a glower without undue strains and which also would permit the transformer to remain in service even if a lamp should fail to light. These requirements have been taken care of successfully by introducing into the magnetic circuit of the transformer an air-gap. The introduction of the air-gap permits a larger primary magnetizing current without heating of the iron on open secondary. It also tends to flatten the current-voltage characteristic on the secondary side, *i. e.*, when glower and heater take current in parallel, as in the case of lighting the lamp, the voltage does not drop to such a point as to be below the voltage for safely starting the glower; strains in the glower are thereby avoided, due to low voltage. On the other hand, the voltage does not go up beyond a certain point at the moment the heater has been cut out of service, thereby avoiding a rush of current through the glower, which might be harmful, especially in cases where the transformer is operated on a higher current than it is intended for.

A feature of the system is the operation of the glowers without a ballast, the constant-current quality of the circuit maintaining the glower at its proper current.

CONCLUSION.

In conclusion, I would like to say a few words regarding candle-power ratings of illuminants. While it is true that the illuminating engineer insists on having the mean spherical candle-power of a light source, on the theory that having a given total flux of light, it may be directed where desired by use of accessories, after all, what is required is light in the useful direction. As is the case with some illuminants, their light, on account of their very nature, being directed in the useful plane, may be of lower spherical efficiency than that of lamps which throw the light in a direction where it is not wanted.

I therefore maintain that it is advisable not to consider the mean spherical candle-power of a lamp, but the mean hemispherical candle-power, as a lamp which may have the higher spherical efficiency when tested without reflecting de-

[1] Results obtained by the Electrical Testing Laboratories.

vices may be much lower in hemispherical efficiency when used in connection with reflectors than lamps which have a natural downward distribution.

Consequently, I am very much in favor of considering the mean lower hemispherical candle-power as the basis upon which to compare illuminants.

In raising this question, I want to bring out a discussion and eventually have some action taken to establish such a standard of rating for illuminants.

The Mercury Vapor Lamp.

By Percy H. Thomas.

IN the recent very rapid advance of the practical development of a number of new types of illuminants and methods of illumination, the mercury-vapor lamp has made a place for itself on account of certain unusual qualities which it possesses. These qualities are so unique and so favorable as to insure this type of illuminant a relatively wide field of usefulness.

The actual source of light in a mercury-vapor lamp is the vapor of mercury at very low tension confined within an hermetically sealed and completely exhausted tube and excited by the passage of an electric current. Except for the fact that means are required for starting and steadying the current, this lamp consists merely of the exhausted tube containing mercury traversed by electric current at voltages ordinarily used for lighting.

From the point of view of the physicist, this lamp is of very great interest, since it utilizes what is practically a new group of electrical phenomena, namely, that connected with the passage of relatively large current (to the volume of a number of amperes) through a vacuous space. In this type of current conductor, the electrons, sometimes called corpuscles, that is,

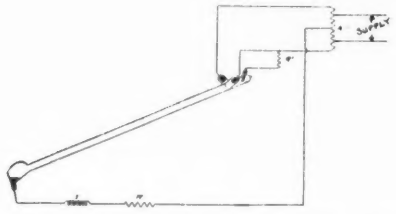


Diagram of Alternating-Current Lamp Circuit.

those very minute particles carrying a charge and constituting electricity, pass from out of the negative electrode (sometimes called cathode), whither they come through the lead of this electrode, pass through the vacuum space like small balloons finding their way from the cathode to the positive electrode (sometimes called anode) among the much larger gas atoms. At the anode they enter the body of the electrode and pass off through its lead to complete their circuit. In their passage through the mercury vapor, which

Mr Percy H. Thomas, Chief Electrician, Cooper Hewitt Electric Company.

though at very low tension always fills every space where mercury is in the neighborhood, these electrons, moving at enormous velocities, violently agitate the mercury atoms, causing them to emit the particular light characteristic of this material.

It is found that although these electrons can pass from the negative electrode into the vapor and from the vapor into the positive without more than a few volts loss of potential, when flow has once been established, yet, before any such flow is established, a very high voltage is required to start the stream of electrons (which means the flow of current) out of the cathode. This starting resistance (often called negative starting reluctance), which is a handicap for the mercury-vapor lamp, may be overcome in several ways: to start the current, for example, by applying a somewhat increased potential across the lamp from a choke-coil and concentrating the strain at the negative electrode by a metallic strip just outside the tube at the level of the surface of mercury and connected to the anode lead; or by bridging the mercury in a thin stream between the two electrodes, letting current flow through this mercury circuit and then breaking the mercury stream while it is still carrying the current. Either method initiates a flow of current which afterwards continues smoothly enough at ordinary voltages, such as 110 or 220 volts.

It is interesting to note that these electrons, which constitute the current, flow from the negative electrode to the positive electrode within the lamp, which direction is opposite to the direction of flow of current as shown by an ammeter. This results from the fact that these electrons are a recent discovery, and when long ago the assumption (in accordance with which ammeters are now calibrated), was made that current flows out of the positive lead of a generator, this was really opposite to the true direction of current, as has since been discovered. Except for these electrons there is practically no definite method of determining which way current does really flow in a circuit.

Previous to the work of Peter Cooper Hewitt, which goes back something over ten years, there had been made no practicable lamps of this character. Some laboratory experiments had been made at infrequent intervals for a good many years with vacuum apparatus containing mercury. None of these, however, showed a workable lamp involving the principles discovered and worked out by Mr. Hewitt. Among those preceding him, Dr. Arons, of Germany, came the nearest to success, by making an exhausted tube with mercury electrodes which would pass a number of amperes at normal voltages and give

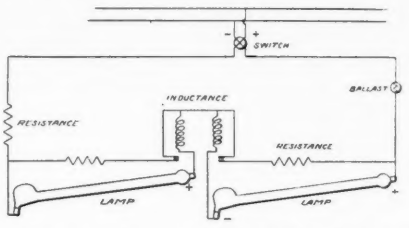


Diagram of Connections for Two Lamps in Series.

light. He succeeded in making a U tube a few inches long which would operate for a short time, giving light somewhat after the method of the Hewitt apparatus, but his tubes were not and could not be successfully used as practical light sources. Until Mr. Hewitt had discovered the law of condensation and restoration of the evaporated mercury and the location and character of the negative electrode starting reluctance, no useful lamp was feasible.

Mr. Hewitt spent a number of years ex-

perimenting with the mercury-vapor tubes and finally arrived at a practical design of apparatus. These lamps have been in use commercially for upwards of four years.

Mercury-vapor lamps have a number of salient characteristics, chiefly the following:

The quality of light given off is unique as regards its color and its diffusion. The color characteristic results from the fact that the light is emitted by mercury in the gaseous form. It is a mixture of four principal colors which on a white surface appear to give a beautiful clear white, but which on colored objects distort the color value according to whether the particular colors present in the object are among those emitted by the vapor. Such colors visible spectrum, as are the red and light violet, the absence of these colors is rather an advantage.

In efficiency the mercury-vapor lamp excels all other artificial illuminants, except possibly the flaming-carbon arc. The commercial efficiency runs from one-half to three-quarters of a watt per candle, depending somewhat upon the method of measurement and the exact adjustment of the voltage of the circuit. The efficiency of the tube itself is about one-third of a watt per candle. This figure is arrived at by dividing the number of watts used in operating the lamp by the candle-power produced therefrom.

At the present time all mercury-vapor lamps commercially available for general

A Foundry Lighted by Mercury Vapor Lamps.

as are there found are brought out brilliantly, while colors not given off by the vapor appear deadened or nearly black. The principal colors above referred to are a yellow, a yellow-green, a light blue, and violet. There is a small quantity of blue-green as well. There is a notable absence of red, the natural result of this being that objects having much red, especially the human skin, have a very much darkened appearance.

These unique color features have a number of results. In the first place they, of course, render the light unsuitable for many purposes where correct color value is required. On the other hand, since the eye usually works best by those colors which are not at the extreme ends of the illumination operate on three and one-half amperes. This current is adapted to a tube about an inch in diameter. Lamps of forty-five inches length of light-giving tube (nominal candle-power, 700) are operated on 110 volts, or, two tubes in series, each twenty-one inches in length (nominal candle-power of each 300), may be operated on the same voltage. For 200 to 250-volt circuits two of the outfits suitable for 110 volts may be run in series.

An analysis of the way in which the energy is consumed in such lamps shows a loss of about ten to twelve volts in the two electrodes together, and the remainder, amounting to about a volt and a third per inch length, is consumed in the vapor column between the electrodes. Each one of these three voltage losses, and consequently their sum or the total loss in the lamp, is nearly constant, independent of the current. The voltage even increases slightly with decreasing current.

This characteristic leads to a very interesting feature of these lamps which they possess in common to some extent with Nernst lamps and arc lamps, namely, that when the lamps are run on constant potential with only a small series resistance (which gives the most efficient condition), a small drop in line potential will produce a percentage drop in current very much greater, in fact, as much greater than the percentage voltage drop as the voltage taken up on the ohmic resistance is less than the total voltage of the circuit. This renders the operation of such a lamp so connected very unstable; so much so that a special device is used with the lamp to overcome this weakness. This auxiliary device, commonly called a ballast, is similar in principle to a device with the same name used with the Nernst lamp, and is so effective as to render operation upon commercial circuits very satisfactory. This ballast is placed in series and, as is pretty well known, has the property of very greatly increasing its resistance with a relatively small increase in current, and conversely of very rapidly decreasing its resistance with a small fall of current. It is clear that such increase tends to absorb an additional line voltage which would otherwise increase the current, and the analogous decrease tends to make up for any drop in line voltage. It should be observed that this device is effective as well against internal changes of conditions within the lamp.

The ballast consists of a fine wire hermetically sealed in a glass bulb about the size of a sixteen-candle-power incandescent lamp and surrounded by hydrogen gas at low pressure. It is found that such a device experiences an increase of resistance of three or four hundred per cent in passing from a temperature slightly below red heat to a dull red; this evidently allows a very great corrective power, since the parts are so proportioned that normal current causes the wire to run at a temperature intermediate between these extremes.

There is a curious property of mercury-vapor lamps operating at currents below perhaps four amperes which makes it necessary to utilize inductance in series therewith. The initial reluctance of the negative electrode to starting has been already described. Even after starting

there is a momentary tendency recurring at frequent intervals tending to extinguish the lamp as long as the electrode remains somewhere near the temperature of the atmosphere and the current does not exceed three or four amperes. This momentary increase in resistance must be met by a corresponding voltage impulse. By utilizing a choke-coil in series with the lamp these momentary impulses tending to put out the lamp cause a corresponding voltage impulse from the choke-coil, in which there has been stored energy available for this purpose in virtue of the initial establishment of the current. A choke-coil thus becomes an important part of this lamp.

Mercury-vapor lamps are most readily run on direct current, for with two electrodes, a positive and a negative and suitable starting arrangements, ballast, resistance and coil, a practicable lamp is obtained, while for operation upon alternating current it is necessary to provide some means for preventing the cessation of current at the zero point of the electromotive-force wave, which would otherwise extinguish the lamp each alternation. This is accomplished, as is well known, by connecting the terminals of a transformer winding to two positive electrodes located adjacent in the lamp and connecting the negative electrode to the middle point of the winding; then during one alternation current will pass from one terminal of the transformer through one of the positive electrodes and back through the negative electrode, and during the next alternation from the other terminal of the transformer through the other positive electrode and back again through the negative electrode. It would appear at first sight that, instead of taking the path through the tube and the negative electrode, the current would pass directly from one positive electrode to the other in virtue of the fact that the whole transformer potential is exerted between these electrodes. But, since the negative electrode starting reluctance of neither of these positive electrodes is broken down, current can not enter either of them, though it can freely leave at any time. Consequently, no short-circuit can occur.

It will be noted also that the currents from both positive electrodes to the negative electrode are in the same direction through the lamp tube itself, and also through the choke-coil, which is placed in the lead from the negative electrode. That is, as far as the light-giving portion is concerned, the lamp runs substantially on direct current. The choke-coil performs a second function, namely, that of steadying the current flow in the tube, which tends to be pulsating on account of the alternating character of the supply, and thus prevents the current ever becoming zero even at the end of an alternation. With the exception of the conditions here mentioned the alternating-current lamp is very much like the direct-current lamp, that is, it usually requires a ballast for best commercial operation, etc.

In its commercial form the direct-current lamps include a small series resistance, a ballast, a choke-coil, a lamp tube, a suitable holder for the tube, and mounting parts. This tube, which is made in various lengths, from twenty-one to forty-five inches, is about an inch in diameter and hangs nearly or quite horizontal. The ballast, resistance, terminal, etc., are covered with a housing, as is usual with such mechanism. The lamp tube is tilted for

COMPLETE DIRECT-CURRENT MERCURY-VAPOR LAMP, SHOWING AUXILIARY PARTS, REFLECTOR, HOLDER AND TUBE.

starting to cause the mercury to run from one end to the other and form a momentary bridge, as has already been explained, The lamps may be made to tilt by hand or by means of an electromagnet forming part of the holder.

When the lamps are run in series, a shunt resistance is provided with each lamp, adjusted to absorb approximately the same voltage as the running lamp, so that the lamps may be started or run separately. As soon as the lamp starts, its shunt-circuit is opened by a small cut-out.

After this outline of the form and characteristics of the mercury-vapor lamp, there remains only a statement of its practical advantages and limitations. This type of lamp, which has been in commercial use for several years, is now sufficiently understood, so that its field of usefulness can be pretty well determined. Broadly speaking, its greatest utility is in industrial and street illumination. Its color usually renders it undesirable where æsthetic conditions are paramount, such as in domestic lighting, public halls and stores. On the other hand, wherever light is required for mechanical processes, especially for inspection and accurate work for clerical offices and drafting rooms, or for lighting large spaces, such as warehouses, piers, power-houses, and such, the mercury-vapor lamp is in most cases the most satisfactory illuminant. The characteristics which are of most value will be briefly discussed.

QUALITY OF ILLUMINATION.

There is an almost indescribable quality about the illumination produced by these tubular lamps which experience has shown to be extremely favorable for practical use. This results partly from the diffusion and absence of shadows, which follow from the tubular form of the light source. It will be evident upon a moment's consideration that each point of a tubular light throws the shadow of any particular object in a different place from the shadow thrown by any other point on the tube, and that conversely any point shadowed from any given point of light on the tube by an object will be illuminated by nearly every other point on the tube, so that as a net result, except for very large objects, shadows are almost eliminated.

Again, from the fact that the light emanates from so large a surface, it follows that no one point is extremely bright and that as a net result looking at the lamp does not have the dazzling and deadening effect upon the eye nerves and sensitive portions of the retina, which is so characteristic of arcs and incandescents, nor is the pupil of the eye caused to contract in self-protection to anything like the extent, as with other light sources. This effect, though in some degree evident, is a much more important factor than ordinarily supposed, since the eye is not able consciously to measure the extreme brilliancy of the arc, and unconsciously has its sensitiveness much deadened thereby.

Furthermore, for fine and exacting work, notwithstanding frequent impressions among people who have not had an opportunity to become used to the mercury-vapor light, experience has shown that its quality is unusually favorable and is without harmful effects of any kind. One feature contributing to this result is undoubtedly the absence of red which, as can be seen by a moment's consideration, is a color very trying to the worker.

ECONOMY.

In addition to the very great advantage the mercury-vapor lamp possesses in virtue of the quality of the illumination produced, it is unquestionably the most economical lamp available for practical illumination. The consumption of current for nominal candle-power has already been given as between 0.5 and 0.75 watt per candle, but this is only a very rough measure of its advantage. The considerations of absence of bright spots and deep shadows renders a given strength of illumination much more useful when obtained from a vapor lamp than when obtained from an arc lamp. The impression on the observer of a space adequately lighted by vapor lamps is not that of brilliant illumination, but merely of the power to see objects clearly. The sensation of brilliant light which is so common in strong artificial illumination, and which a moment's consideration will show is not the main object sought, is usually absent in these installations.

It is found by actual experience that three five-ampere enclosed-carbon arcs can usually be replaced by two of the mercury-vapor tubes consuming three and one-half amperes each at 110 volts with an illumination decidedly superior for practical purposes. It is usually a fact that where mercury-vapor lamps are substituted for other types, it is with the purpose of improving the quality of lighting previously existing, and it has been found in practice almost invariably that at the same time a very marked decrease of current consumption is secured.

Different sorts of work require very different strengths of illumination; from large warehouse spaces, where one of the three-and-one-half-ampere, 110-volt lamps will light perhaps 6,000 square feet of floor space or even more, to make-up tables in printing establishments where such a lamp will not be expected to cover more than 300 to 500 square feet. On this account it is impossible to give more definite figures as to the current actually required to light a given area.

The matter of first cost and maintenance, as well as the consumption of current, is important in determining the economy of a lamp. The first cost of mercury-vapor lamps is greater than that of arcs or incandescents, but in general the cost of installation may be less, on account of the reduced number of outlets and the simpler wiring. In an installation which is already wired, utilizing old outlets, with cost of current not lower than three or four cents a kilowatt-hour, the saving in current and maintenance secured by the substitution of mercury-vapor lamps will ordinarily pay for the lamps in a year, where the use is over six or eight hours a day. In cases where wiring is to be done to suit the lamps chosen, it will often be found that the total cost of installation of mercury-vapor lamps is not more than of arcs or incandescents.

In the item of maintenance the mercury-vapor lamp has a very great advantage; practically the only part requiring renewing is the tube itself. As there are no moving parts except the tilting holder, and in automatic lamps the plunger of the magnet, very little attention is required. Naturally the tube has a practically infinite life, although, of course, there must be an actual limit to the life of all tubes. Variations in materials, manufacture and usage cause considerable variations in the life of the tubes. The only feasible way to determine the practical data on this question is from actual installations. A compilation of data on the time of actual burning of the various tubes used has been made from some five important installations. Two of these are newspaper offices, one an accounting office, one a large post-office, the other general illumination in mercantile buildings. Omitting the earliest lamps furnished these places, where the records are not so satisfactory, in these establishments the average time of actual burning up to the time of compilation, taking into account all lamps furnished to date, were as follows:

Installations No.	Number of Tubes.	Average Hours.
1	150	3,287
2	181	4,860
3	148	5,730
4	50	4,310
5	6	9,050
Total tubes....	530	Aver. of all tubes 4,633

Many of these tubes are still burning. Among these 530 tubes there are twenty-eight lamps having a life exceeding 10,000 hours actual burning, many of which are still in service. The maximum length among these particular tubes was at the time of compilation 15,000 hours. In another installation there are at least four which have run 18,000 hours. There are a number of other installations in which the average life is probably very little less than the average given above. As has already been stated, the lamps do not have perfectly uniform life characteristics, some units having a relatively short life, but, except under unfavorable conditions, the average life of these tubes is so great that the item of the cost of renewing the tube is of relatively little importance.

It will thus be seen, since these lamps require a minimum of attention, that they will have a low maintenance cost.

REGULATION.

The question of regulation has already been touched upon, but it is worth while to state that in spite of the naturally unfavorable characteristics of the lamp tube itself, the effectiveness of the ballast, which is furnished as a part of the outfit, is so great that the mercury-vapor lamp is probably the most satisfactory of all electrical lamps as regards its performance on varying line voltage. Variations of ten per cent, or even more, in voltage, produce a hardly noticeable effect upon the candle-power, and do not cause unsteadiness in the light. This can hardly be said of arc or incandescent light.

The description here given of the practical utility of the mercury-vapor lamp may be summarized by the statement that for practical utilization, where true color value is not necessary, the mercury-vapor lamp gives a very satisfactory quality of illumination, has a character favorable in its physiological effects upon the eye, and is at the same time the most economical to operate and the simplest to maintain of the electric lights available for industrial illuminations.

Recent Developments in Metallic Flame Arc Lamps.

By G. Brewer Griffin.

SINCE the discovery of the phenomena of the electric arc by Humphrey Davy, and after the time of the development of the arc machine, there has been a constant effort on the part of the designers and manufacturers of arc lamps to decrease the cost of maintenance and increase the luminous values, as well as the efficiency of the light. The early experiments with the Jablochkoff candle, which consisted of a combination of carbon and kaolin, was a feeble effort to start along the right lines. But Jablochkoff experienced the same difficulties in the operation of oxides and carbons as has been experienced in the earlier forms of metallic arc lamps, or luminous arc lamps of the present day; namely, the tendency

of the material to slag over, so that when the effort is made to start a lamp the second time, considerable energy is required to burn through the non-conducting substance which is represented by the slag. The present-day type of lamps have this trouble to a greater or lesser degree, but by proper combination of chemical substances this trouble can be entirely eliminated, provided the electrodes used bear the proper relative position to each other. This tendency seems to be much greater when the consuming element is the lower element of the lamp.

The first of the so-called "magnetite electrodes" which were put in service showed an irritable tendency to slag over, which caused the manufacturers of the first lamps to introduce a movable metallic element whose function it was to break off the slag which has formed in order to allow the arc to establish itself. The lamp described herein owes its successful operation to the careful manner in which the chemical properties of the electrodes have been studied when operated in the electric arc. The electrodes used are of metallic oxides and are commonly referred to as "magnetite," as the black magnetic oxide of iron is commonly used as the principal ingredient. In addition, it has at least two other oxides; namely, oxide of titanium and oxide of chromium. Instead of being molded in a plastic form and squirted in a die, as are carbons, these metallic oxide are carefully compounded together in correct proportions and by special means packed tightly in a steel containing tube, the end of which is sealed with an electric arc. Titanium oxide has been found to have the property of rendering the arc luminous, and as the flame from the ixodes is like a candle flame, the light does not come from a crater as from carbons, but from a conical flame, which has its luminous and non-luminous zones; the diffusion of light from the luminous end being aided by a reflection from a button or puddle of molten metal retained on or near the fused slag, which becomes highly reflecting. The flame from this arc can in general be compared to the candle flame in shape, both flames being a sort of hollow cone, in the candle the luminous part of the flame being the upper part, and in the metallic arc the lower part, provided the lower element is the positive and the upper element the consuming one. Obviously, considerable is gained in the distribution of the light by the reflection from the molten button of fused slag.

The non-luminous zone can be decreased and the luminous zone increased to a certain extent by the addition of urea crystals in the composition of the electrode. The oxide of chromium prevents too rapid combustion and is a necessary ingredient in order that the electrode may have a long life. The oxide of titanium has a similar action in the arc as do the rare earths or metallic oxides used in gas mantles which become highly luminous when heated. The hollow cone-shaped flame, therefore, could be compared to the incandescent gas mantle so that, unlike the arc obtained from the operation of a pair of carbons, which rather obstructs the light developed by the craters, the arc itself in the case of the metallic-oxide flame becomes highly luminous, so that an increased useful light efficiency is obtained without an increased amount of energy being required.

FIG. 1.—METALLIC FLAME ARC LAMP.

FIG. 2.—METALLIC FLAME ARC LAMP.

As a matter of fact, while an enclosed-carbon lamp will not burn properly with the arc voltage very much under seventy or seventy-two volts, the metallic arc will burn well with less than fifty-five volts, although it is commonly adjusted to operate at from sixty-five to seventy-five volts, while carbon arcs are ordinarily set at eighty volts. Further, the ordinary carbon arc used for street lighting requires from 6.6 to 7.5 amperes and a seventy-five-volt arc to produce a light comparable with the above-described lamp operated at four amperes and sixty-five volts.

The life per trim of the metallic-oxide electrodes is only limited by their length. Twelve inches of active material will give more than 175 hours' life, as compared with an equivalent length of carbon in the carbon arc which will only operate from 100 to 125 hours. In addition, the metallic arc operates at a uniformly "white color" (so-called), which is in marked contrast to the changeable colors of the enclosed-carbon lamp; namely, from "white" to blue and violet.

The lower element of these lamps is made of convoluted strips of laminated copper and iron, and is the same diameter as the upper element; namely, one-half inch and about one inch in length. It is desirable that this element be changed for a new one each time the upper, or negative element, is placed in the lamp. As this lamp feeds in a manner similar to the well-known down-feed carbon lamp, it readily lends itself to the use of sticks of various lengths, so that for special purposes, lamps could be built which would give a life per trim of 300 or more hours, while in the earlier forms of similar lamps, the life is limited by the length of electrode which can be inserted in the lower holder. The down-feed type of mechanism is naturally much more simple than the under-feed mechanism.

Another point of difficulty which has been overcome in the lamp described, and which is present in the under-feed type, is getting out of the lamp the reddish spongy soot or oxide which is thrown off by the arc. As in the form of lamp here described, the arc maintains the same relative position in the globe from the time of starting until the element is entirely consumed, the arrangements of ventilating ducts and drafts through same, drawing the oxides out of the lamp, can be ar-

ranged with mathematical exactitude, while with the under-feed mechanism such an arrangement is difficult, if not impossible to make, owing to the change in position of the arc in relation to the chimney or outlet tube as the element burns away.

Another desirable feature attained by burning the electrodes with the negative above is that it brings into service the bright zone of the arc flame in such a position that there will be practically no shadow thrown by the electrodes, and that the gain in useful light reflected from the brilliant pool of fused slag can be thrown down and out and be utilized instead of being thrown up and wasted.

It was found necessary to develop a downward draft of air in the lamp which would reverse when coming in contact with the heat of the arc and flow through the ventilating tube.

This draft system is, as before pointed out, the feature which has made this lamp superior. In the carbon arc the volatilized impurities from the carbons are deposited on the nearest cool surface adjacent to the arc. While some attempts were made by certain arc lamp manufacturers to use gas caps of substances having a porous nature which would rapidly conduct away the heat and still not admit air by leakage, thus furnishing a comparatively cool point for the condensation of these silicates, most manufacturers have done nothing in this connection on account of the expense incurred, but insisted on the carbon manufacturer furnishing carbons with a minimum amount of impurities, which finally became as little as 0.2 of one per cent. With the metallic arc electrodes, composed as they are of the oxides of iron, titanium and chromium, they do not burn away to an invisible gas as does the carbon, but are volatilized bodies, the vapors of which instantly condense by leaving the arc in a fluffy reddish soot as referred to above. This soot settles and adheres firmly in a film to anything which it touches and rapidly piles up after a film is once formed, so that a chimney with a carefully designed draft is a very necessary feature in this type of lamp, in order that the soot may not come in contact with the reflector and globe, as it would smudge them badly in a few minutes and cause a considerable loss in available light.

In this lamp the current of air is constantly flowing down around the electrode and serves to keep it clean, and is also applied to the reflector and globe with gratifying results. The thin layer of air which is introduced in the top of the reflector, forms an air-shield through which the soot-laden air can not penetrate, thus the reflector and globe keep clean for a long period.

Another function of the air draft surrounding the arc is that it centres the arc, holding it remarkably steady and quiet. Reverse currents of air are impossible, and while the intensity of the wind naturally affects the force of the draft, high winds cause no trouble, and are, if anything, advantageous, as they increase the speed by which the by-products of combustion are removed from the lamp.

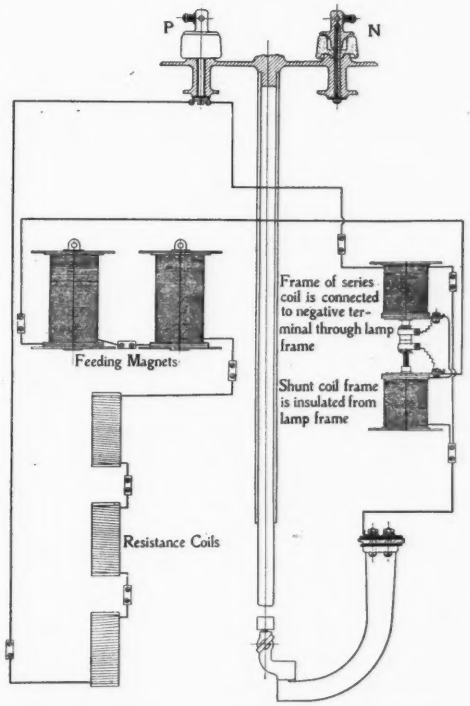

P
N
Frame of series coil is connected to negative terminal through lamp frame
Feeding Magnets
Shunt coil frame is insulated from lamp frame
Resistance Coils

FIG. 3.—DIAGRAM OF INTERNAL CONNECTIONS, METALLIC FLAME ARC LAMP.

Being designed primarily for out-of-door service, the lamp has a rugged and symmetrical appearance. It is designed to meet the requirements of the central stations as to the ease with which it can be repaired, trimmed and cleaned. The globe is held by a heavy ring of metal, which in turn is pivoted to a second ring, which second ring is fastened to the lower body by a substantial hinge, so that the locking device may be tripped with one hand, the globe falling by gravity—emptying any deposits which may be therein, automatically. The operating elements can then be inserted with one hand and the globe tipped up and closed. (See Figs. 1 and 2.)

Fig. 3 shows the diagram of the connections of the lamp, which operate as follows:

The electrodes, when out of use, stand separated and the cutout contacts closed. The upper cutout magnet is in series with the arc, and the lower magnet is in shunt across the arc. The striking or feeding magnets are in series with the starting resistance and the armature of this magnet is connected to the dash-pot with a graphite self-lubricating plunger.

When the current is turned on it passes through the feeding magnets, which pull down their armature, bringing the two electrodes into contact, thus causing the current to pass through the series magnet, lifting the series cutout contact away from the shunt contact and breaking the circuit through the feeding magnets. This releases the armature of the feeding magnet and the electrodes are drawn apart and the arc established. As the arc lengthens, due to the burning away of the electrode, the shunt magnet becomes energized finally to a sufficient degree to lift the shunt cutout contact until it touches the series contact, energizing the feeding magnets and reestablishing the arc at its normal length.

It might be pointed out that in this lamp the arc with less energy will probably operate at a temperature equally as high as the carbon arc in spite of its greater energy consumption, owing to the fact that carbon is a comparatively rapid conductor of heat, and in the enclosed lamp a relatively large body of carbon is exposed to the flame action of the arc and the heat generated by the consumption of energy is rapidly dissipated by the carbons themselves, while in the metallic arc the heat is dissipated to a comparatively inconsiderable extent, owing to the low heat conductivity of the elements used.

It should be understood that the metallic oxide in the consuming element is only disintegrated at the point of contact with the arc flame, which is at a point, and as the production of light is, as has been demonstrated, the result of heat, the greatest luminosity can be obtained when the maximum amount of heat is centred on the minimum amount of material. This has been well accomplished in the lamp described. The lamp therefore has a high light efficiency by having substances in the electrodes, the vapors of which not only serve as a current path, but possess the property of selective radiation to a high

degree. The arc stream, operating at a high temperature, gives the maximum of light for the minimum amount of current expended with a color and quality of light which the average observer claims to be the best; namely, "a white light," or, in other words, a light which has a spectrum as near as is possible artificially to sun light. The angle of light below the horizontal, as compared with other types of arc lamps, is represented by the following table:

Type of Lamp.	Arc Voltage	Color.	Angle Below Horizontal.
D.-C. open....	48	White	45°
A.-C. open....	39	White	25°
D.-C. enclosed.	78	All white	30°
A.-C. enclosed.	72	All white	15°
Metallic flame.	84	White	10°
Flame carbone	65	Yellow	90°

A 275-watt metallic flame lamp will successfully replace a standard 7.5-ampere enclosed-carbon lamp, and on account of its superior distribution will give a more uniform street illumination than a carbon arc, and if used to replace carbon arcs, the distance between lamps could be increased fifteen per cent and still secure an illumination at mid distances between lamps superior to that given by the carbon lamps at about one-half the energy of consumption.

The lamps above described are primarily designed for street-lighting service and are distinctly direct-current lamps for operation in series. They can, therefore, be operated from any constant-current arc machine or, to follow the latest practice, from alternating-current machines by current delivered to the line through mercury-arc rectifiers.

Briefly described, the current is taken from an alternating-current generator and carried to a repulsion coil-regulating transformer; from thence through the mercury rectifier to the lamps. The efficiency of the alternating-current repulsion coil regulating transformer and mercury-rectifier outfits is approximately ninety per cent and are designed for 7.5 per cent line loss. They are furnished for circuits of twenty-five, fifty and seventy-five-light capacities.

The Moore Light and Illuminating Engineering.

By D. McFarlan Moore.

IT is the purpose of this article to prove from a number of the most essential standpoints that the Moore Tube Lighting System well deserves the title of "The most advanced form of illumination," and that the fundamental principles upon which it has always been based are identically the same as those which, at last, are now being given the most prominence in the present great wave of attention to the engineering problems involved in rational artificial illumination. Fourteen years have now passed since the writer first began to advocate the theory that the entire fabric of correct artificial illumination should rest upon the simple precept, *viz.*, try to most closely imitate natural light.

Tube lighting approximately imitates daylight in diffusion, because the area of the light source has been multiplied hundreds of times. For indoor illumination the extreme development of the daylight imitation idea resolves itself into attempting to make the entire ceiling the source of illumination, to which procedure long vacuum tubes lend themselves most admirably. Even a cursory investigation of the trend of the applications of most of the other forms of light show that they, too, are striving for the same goal, and that the day of elaborate pendant fixtures is very rapidly and rightfully passing.

Ruskins' teaching, "that the highest art is simplicity," is being appreciated, and the demand is for stores, for example, that from their entrance present an open and lofty aspect, which is only obtained by having practically no fixtures, and the source of the illumination almost against the ceiling. Further than this, the illuminant itself becomes less and less obtrusive, more and more like natural light, the lower its intrinsic intensity. In this respect the Moore light is several hundreds of times better than any other widely applicable form of light. The absence of all bright centres of light is very pleasing, and the necessity for small individual sources of light comprises only about ten per cent of the total of the electrical indoor lighting field. Therefore, the most important problem of the illuminating engineer concerns the production of an even illumination over large areas, and naturally such problems can not be solved better than by utilizing the light source of maximum area—*viz.*, long vacuum tubes.

MR. D. MCFARLAN MOORE, CHIEF ENGINEER AND GENERAL MANAGER, MOORE ELECTRICAL COMPANY.

Color is the second most prominent factor in daylight imitation, and the problem can be said to have been thoroughly solved when, for example, experts in color matching are unable to detect any difference between the Moore tube light, fed with carbon dioxide, and average daylight. This has been the experience of one of the largest silk dyeing establishments in this country after having unsuccessfully tried all other forms of light.

For some time past artists have been mixing their colors at night under the white Moore light. Natural light varies over wide ranges. Not only does the bluish-white diffused daylight vary from hour to hour of the day, but it should be remembered that bright yellow sunlight in the open air is also natural light. It can best be imitated by feeding a Moore tube with pure nitrogen.

Drapery and millinery stores should use an illuminant as near to daylight as possible. Diamonds display their sparkling properties better under a pure blue-white Moore vacuum tube than under any other light.

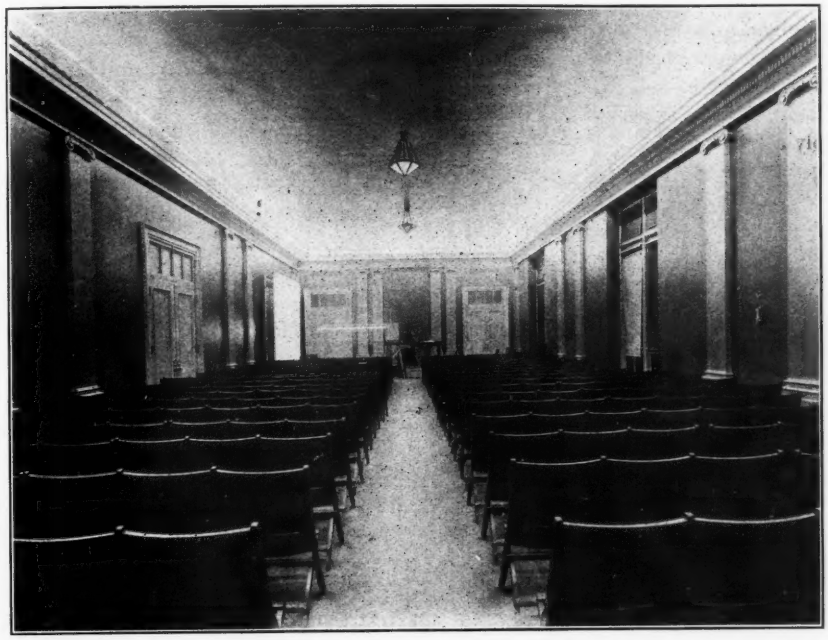
The higher refinement of illuminating engineering is bringing into view more and more prominently the colors all light sources give to surrounding objects.

Art galleries have long been sadly in need of an imitation of daylight. Since all of the great works of art, representing fabulous values, were executed under natural conditions, it is necessary, if the spirit of the painting be grasped, that it always be viewed under like conditions.

Another salient quality of natural light is its steadiness. It is true, its intensity varies from daybreak to sunset, but it never changes suddenly, therefore, an artificial imitation must have an intensity that is perfectly constant from second to second, and not one that flares and flickers as do arc lamps. The light from long

vacuum tubes is even steadier than that of all forms of incandescent lamps, because the tube is much less affected by voltage variations.

The advance that has been made as regards safety from fires, from the oil lamp on a table to a harmless vacuum tube rigidly and permanently attached to the ceiling, can not well be exaggerated. With the general adoption of vacuum tube lighting, insurance rates will gradually be lowered. It is now possible to light large department stores, for example, without having an inch of wire within their walls, by the utilization of the harmless, long Moore glass tubes, and thereby eliminate about ninety per cent of the dangerous, costly and objectionable wiring now so extensively used. This fact is particularly pertinent in regard to the lighting of not only new buildings, but also old buildings.



LECTURE ROOM IN UNITED ENGINEERING BUILDING DURING DEMONSTRATION OF MOORE TUBE.

Not long ago the statement that daylight costs us nothing would have been considered a truism, but not so in this age of congested districts and skyscrapers. However, theory indicates that we should still very greatly cheapen the cost of producing the different rates of ether vibrations necessary for us to see objects.

CHINA AND CROCKERY DEPARTMENT, ILLUMINATED WITH MOORE TUBE.

Economy is really the main practical reason why we still use old-style spots of light, and do not resort entirely to general lighting sufficiently bright for all ordinary purposes. But since it is a fact that it costs a number of times as much to illuminate an average large area with incandescent lamps as with the Moore vacuum tube system, even in its present stage of development, the laws of evolution will gradually bring about a greatly reduced use of small units of intense light and substitute therefor tube lighting which is worthy of the name "artificial daylight."

We can determine with great exactness the efficiency of various kinds of electric motors for changing electric energy into mechanical energy, but when we attempt to state the comparative efficiencies of various kinds of electric lights for changing electric energy into the form of what we call useful light, immediately we have entered a field of an incomparably lower order of exactness, because not only the area of the light source and its color, but also the objects illuminated, become of prime importance. This fact is largely responsible for our belief that illuminating engineers will forever be in great demand.

Therefore, the first essential feature should be constant local conditions, in the attempt to obtain a simple numerical figure for each system of illumination that would truly express its cost of operation, that is, its efficiency, from a comparative commercial standpoint. Dividing the average hefner-feet of the plane illuminated by the watts per square foot, gives this "illuminating efficiency." It should have no other name. Such a test covering most all of the present-day methods of lighting has never been made, but when it has been done authoritatively and in a thoroughly disinterested manner, data valuable, and practical and specific concerning actual results will have been obtained. Such a test would set at rest much of the present-day discussion, more or less acrimonious. It is largely influenced by training and a tendency to place prejudices and personal opinions ahead of indisputable facts. Some comparative tests of this general nature, that are dependent on the average measurements of the illumination found throughout the area lighted, and not in the measurements of the illuminants themselves, have been made between incandescent lamps and arc lamps and

Moore tubes, and it is believed that the tubes would continue to show their superiority in such tests over every form of illuminant known.

One illustration shows the meeting hall of the American Institute of Electrical Engineers, equipped with a Moore tube 176 feet long.

The second illustration shows one-fourth of the basement of a large department store where the tubes have supplanted arc lamps, and have not only greatly improved the lighting, but also effect a saving of about $1,300 per year in the current bills.

Several of these tubes have recently been changed from the sunlight, yellow nitrogen color to the diffused daylight, bluish-white carbon dioxide color, in order that the delicate shades of color of the beautiful china-ware appear exactly as they would in daylight in their show windows. Such results have never been accomplished before, and I do not belive that carbon dioxide will ever be compassed as the best means for imitating average daylight color values.

The first cost of a tube lighting system is already less than an ordinary incandescent lighting system, designed to produce approximately the same result over a large area. But in connection with first cost, it should be borne in mind that the life of a vacuum tube system is indefinitely long. On account of the great simplicity of the tube system, there is a great saving in the lamp fittings and renewals, chandeliers, shades, switches, wires, etc.

The effect on the central stations of the installation and use of a non-portable lighting source that is really a part of the premises, will gradually be determined.

Each improvement of the present day, as well as the history of artificial light from the beginning, prove that we are simply approaching an equivalent of daylight in all respects. Abundant light is becoming more of a necessity and less of a luxury every day. Yet the appetite for light has not been anywhere near satiated in any city in this country.

Most stores in congested districts, where daylight is at a premium, are now apparently better lighted at night than in the daytime. Tube lighting will correct this evil and make not only basements, but each of the floors of department stores, appear as if they were all provided with skylights.

The best proofs that the vacuum tube is right, both theoretically and practically, are obtained by simply noting the various stages of advancement or evolution of all other forms of light, and drawing the logical conclusion, *viz.*, that the tube-lighting system is a natural climax. All admit that incandescent gases will also be the ultimate source of the most efficient illumination.

Over two and a half miles of Moore light tubing is now in successful, everyday use, including several installations recently made in Europe. They have invaded almost every department of trade; gents' furnishings, dry goods, silks, china, photographers, hardware, amusement parlors, house furnishings, art, clothing, baths, florists, photographic printing, restaurants, show windows, hotels, schools.

In basements in summer time the fact that only about one-sixth as much heat is dissipated as would be if incandescent lamps were used, is a matter of prime importance to the problems of ventilation and the health and efficiency of employés, as well as the comfort of the public and the amount of business possible.

These tubes can be successfully exposed to the summer's sun, or icicles, or be submerged under water. They are applicable to mills, factories, foundries, etc., because neither moisture nor fumes affect them.

It is clear that long tubes would ideally illuminate thoroughfares, and many miles of continuous tubing will finally illuminate our streets in order to obtain at night a diffusion really comparable with daylight.

There are few cases, indeed, where manufactured light is needed, that daylight would not be preferable, and therefore the form of artificial light selected should be the one most nearly resembling it.

Recent Developments in Direct-Current Vertical Edgewise Instruments.

By H. W. Young.

THE increasing importance of economy in switchboard space, especially in the larger stations, has developed a demand for indicating meters of such dimensions that they can be mounted in close proximity to each other or in groups of three or four mounted on a single frame. By this construction a large number of generator or feeder instruments can be installed on a panel, as contrasted with the usual switchboard construction in which the instruments take up a very considerable amount of valuable space.

In view of this well-recognized demand manufacturers have directed their efforts toward producing a vertical edgewise type of meter having a narrow case, and as a result of these efforts a complete line of direct-current meters having cases of but three inches in width have been developed and used to a very considerable extent. In view of the increasing demand and use of this type of meter, the following description of the latest developments along this line may prove of interest, especially to those operating stations where space is valuable.

Both ammeters and voltmeters are of the permanent magnet moving coil type, employing a fixed magnet with pole pieces so arranged as to form a magnetic field within the influence of which is pivoted a suitably designed coil.

Fig. 1 illustrates the general construction and arrangement of the various parts. The magnets are provided with soft-iron pole pieces securely clamped in position and separated by a uniform air-gap. The moving coil is wound on a rectangular aluminum shell and so pivoted that it encloses the upper pole piece, the lower half of winding being centrally located in the magnet gap.

The meter depends for its action upon the fact that the magnetic field generated by current passing through the pivoted coil is in magnetic relation to the field generated by the permanent magnets and according to the well-known law that two magnetic fields tend to set themselves in line with or parallel to each other, the field of the pivoted coil tends to move it out of or across the permanent magnet field and produces a deflection of the indicating pointer.

This coil movement is opposed by the restraining force of the controlling springs which tend to return the indicating pointer to zero position and the moving element thus takes up a position where the displacement is just sufficient to re-establish equilibrium. This relation affords a ready means of measuring current values in which the indicating pointer deflection is directly proportional to the cur-

rent passing and these values are read on a suitably graduated dial.

The design readily lends itself to construction for voltmeters by using fine-wire windings on the pivoted coils in series with high resistances, or for ammeters by using fewer turns of slightly heavier wire in series with a calibrating resistance and shunted across a known resistance such as offered by the usual shunt.

It is highly desirable that indicating meters be highly dead-beat or "aperiodic," so that readings can be quickly and accurately taken. This is especially true of meters used upon lighting circuits where any variation of the voltage must be quickly noted. The highly dead-beat or "aperiodic" qualities of the meters herein described are due to the damping action resulting from movement of the rectangular aluminum frame across the permanent magnetic field, which acting in opposition to the generating magnetic field (such as offered by the permanent magnet field) tends to damp and prevent oscillation of the closed conductor. This form of damping system is simple, effective and introduces no errors in the calibration.

The moving element consists of a suitable winding closely fitting the rectangular aluminum frame which, in turn, is fastened to a framework having highly polished steel pivots resting in jeweled bearings, this framework also supporting the indicating pointer. The two special alloy springs in addition to conducting current to and from the windings, also serve as a controlling or restraining force. These springs are mounted on the stationary supporting bracket, an arrangement which relieves the pivoted element of their weight.

The moving element is carefully balanced and its light weight, in conjunction with the highly polished bearing surfaces, offers a bearing system having practically negligible initial friction and one not easily damaged by transportation or installation.

Voltmeter moving coils are wound with fine double silk covered copper wire securely held in position by an insulating varnish, preventing fibers of insulation from becoming loose, rubbing on the pole faces and introducing friction errors. The ends are soldered to the outer end of the conducting springs, the other end of the springs being soldered to suitable supports from which connection is made to binding posts and resistances. Ammeter coils have fewer number of turns of heavier wire mounted and secured in a manner similar to the voltmeter coils.

Differential voltmeters are equipped with differential armature windings wound for opposite polarity and mounted

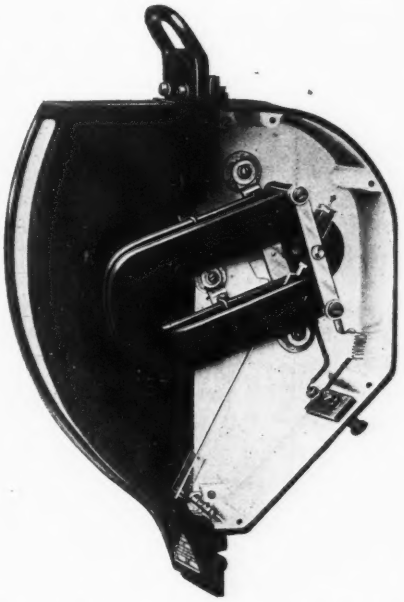


FIG. 1.—INTERIOR CONSTRUCTION OF THREE-INCH VERTICAL EDGEWISE METER (METER REMOVED FROM MOUNTING FRAME).

on a common pivoted frame, two ends of windings being connected to binding posts through the controlling springs, the third winding being connected to its bind-

FIG. 2.—THREE-INCH VERTICAL EDGEWISE AMMETER, MOUNTED IN FRAME.

ing post by means of a short, flexible conductor.

The unbalancing of a three-wire circuit is indicated by the pointer deflecting to either side of zero, and when adjusting generators for parallel operation the control devices are manipulated until the meter indicates zero, showing equal potential of the line and incoming machine.

It will be noted that the magnet system is so constructed that there is but one air-gap instead of two gaps in series, and the magnets can be aged after assembling with the pole pieces. The initial air-gap and magnetic values thus remain undisturbed and insure a system much more permanent than can be obtained by any construction necessitating assembling of pole pieces or setting of air-gaps after the magnets have been charged and aged.

The meters have a high "torque" or turning moment, permitting use of heavy control or restraining springs which, in conjunction with the light moving elements and jeweled bearings, insure sensitive measuring elements which quickly and accurately respond to the slightest changes of load or pressure.

The meter indications are practically free from the disturbing effects of stray or external magnetic fields generated by heavy currents or magnetic material in proximity to the meters.

This freedom from disturbance is secured by the magnet construction which gives an intense concentrated field much stronger than any probable field to which the meters would ordinarily be subjected.

Owing to the extremely low energy consumption and use of low temperature coefficient metal in the resistances and shunts, the meters are practically free from errors due to self-heating of coils or variations of external temperature.

The scales are practically uniform throughout their entire area and very satisfactory as to length, legibility and distribution. The main calibration points are accurately determined by direct comparison with known standards and the intermediate points or subdivisions carefully interpolated, after which the scales are hand-drawn—no printed scales being employed.

The scales are mounted on metal plates having a recessed centre in which the index of the indicating pointer is located, thus bringing the divisions close to the index points and avoiding errors due to parallax.

Fig. 2 illustrates a three-inch meter mounted in its single unit frame. As will be noted, the meter is provided with a handle by which it can easily be lifted from the supporting frame when it is desired to make tests, repairs, or make changes in capacity.

REVIEWS OF CURRENT ENGINEERING AND SCIENTIFIC LITERATURE

Lightning Conductors.

One of the most noticeable features in the accounts of thunderstorms, it seems to Frank Broadbent, is that the buildings most often struck and damaged by lightning are those which are provided with lightning conductors. The prevalent idea in the lay mind is that lightning conductors exist for the purpose of attracting the lightning and providing for it a safe path to earth, thus protecting the surrounding neighborhood. However, a perfect lightning conductor, if it properly performs its functions, ought never to be struck by a direct flash of lightning. If a tall mast be erected with a very good earth connection, and terminating at the top with very fine points, this mast would form an electric leakage path from the earth to the positively charged clouds, and the potential near the mast should never rise to such a value as to cause a dangerous flash. When a building is provided with a lightning conductor, no matter how erected, it is the popular belief that this building should be immune from accident due to lightning, whereas, if the earth contact be bad, or if the top of the conductor terminate in a large compact mass of metal, or if the conductor take a tortuous path, the building is probably in a more unsafe condition than it would be without such a conductor. Even if a building be provided with a conductor as perfect as human ingenuity can make it, there is still considerable risk of damage in the event of the conductor being struck by a side flash, when masses of metals, such as water tanks, lead roofs, gas or water pipes are in the vicinity of the conductor and are not properly earthed. Moreover, a conductor may have a many-pronged top and make a good earth, but have a pretty bend around a coping or ledge, which is a vice that counteracts all its virtues, as a lightning flash will prefer to pass through several inches of masonry rather than take what might seem an easier path around it. It is suggested that all lightning conductors should be tested for earth, and that all metal work, such as gutter spouts, down spouts, railings, piping, etc., should be metallically connected and earthed quite independently of the lightning conductor; that the lightning conductor should be free from sharp bends or kinks, and that its path to earth should be as straight and direct as possible. If it can be erected near to, but quite separate from the building, so much the better for the building.—*Abstracted from the Electrical Review (London), August 23.*

Three-Phase Power Supply for the Manchester, England, Corporation.

Manchester, England, has always been one of the most powerful strongholds of the direct-current system of supply, and has always been regarded as an efficient example of what could be done with multiwire distribution. In spite of this, the Manchester Corporation has, within the past six years, established one of the largest municipal alternating-current systems in England, that is now supplying polyphase powers direct to consumer's premises. The Stuart street station was formerly laid down to furnish a large number of substations with three-phase power, and this was converted to continuous current and distributed to the tramway feeders the electric lighting and power for three-wire network. During the last eighteen months, however, a large number of power consumers have been connected up direct to the three-phase mains, and energy is supplied without any other change than the reduction of the transmission voltage. The Stuart street station contains 27,000 horse-power of equipment, consisting of low-speed vertical engines and field-wall alternators. A 6,000-kilowatt steam turbine is now being installed and will be shortly put into service. Approximately 10,000 horse-power of this plant is at the disposal of the power supply, the remaining and greater portion taking the traction and lighting loads. The methods adopted for supplying power consumers have been especially designed with reference to economy of main feeders. Where a consumer lies on the route of extra high-tension feeders from the main station to the substation, one cable is looped into the consumer's substation. Duplicate cables for lighting and traction always run between the main and substations with distinct sets of busbars for each section. At the substation selector switches are provided, by which the duplicate cables can be coupled to either the traction or lighting bars, and as the same bars are also fitted with coupling switches, a number of changes can be rung on the supply to the consumer through the looped feeder. The consumer's substation equipment is arranged for polyphase supply entirely. If private plants have already continuous current in use, and the motors are too numerous to replace with alternating-current machines, provision is made in this substation for suitable converting plants to transform the transmitted alternating-current into continuous. The ultimate capacity of the substation determines approximately the type of the equipment. The building, which may be any dry, disused premises, or one specially built for the purpose, contains a high and low-tension switch gear, and groups of static transformers. The transformers and high-tension switch gear are divided from the low-tension board by an iron grating. The transformers are of the air-cooled, radiating, single-phase type, the standard size being 200 kilowatts, thus make compact converting units, being free from oil insulation and requiring no attention. Each transformer is mounted on four wheels, which facilitate moving it about. Five tappings are brought out on the low-tension side, giving the voltages from 380 to 420 in steps of ten. Where continuous current is to be supplied to the polyphase mains, some form of rotary transformer, usually a motor converter, is employed. The use of these machines dispenses with the necessity for reducing transformers, as the transmission voltage can be applied directly to the motor.—*Abstracted from the Electrician (London), August 23.*

Comparative Cost of Steam and Hydroelectric Power.

In this article W. O. Webber refers to a preceding series of articles by H. von Schon, reviewed in the ELECTRICAL REVIEW of April 13. In the main the author agrees with Mr. von Schon, but points out that in such comparisons no account has been taken of the land on which all power plants must be situated, and while the cost of buildings is gener-

ally placed too low, nothing at all is allowed for the construction of proper chimneys. He says that for a ten-horse-power plant Mr. von Schon's building is estimated to cost $400, while this figure would merely build the chimney for such a plant if erected in an urban district. On the other hand, if a semi-portable boiler is assumed so as to save the cost of building a chimney and the boiler setting, the extra fuel costs would more than make up the fixed charges of a return tubular boiler. He has found from experience that with coal at $4 a ton the cost of steam power at the engine wheel is almost exactly double the cost of fuel alone. Actual experience has also shown that with coal at $2.50 a ton the rates per horse-power-hour average from 4.65 cents for ten horse-power to 2.2 cents for eighty horse-power. With coal at $4.50 per ton the corresponding rates are six and 2.92 cents per horse-power-hour. Mr. Webber gives tables compiled from actual installations, showing what the costs of small plants are. These average from $230 per horse-power for a ten-horse-power plant to $175 for an eighty-horse-power plant. The total cost per horse-power-year, not excluding fuel, is $92.20 for a ten-horse-power plant, and $40.10 for one of eighty horse-power. Adding the cost of the fuel, the total cost per horse-power-year with a ten-horse-power plant varies from $195 with coal at $5 a ton to $133.42 with coal at $2 a ton. The corresponding figures for an eighty-horse-power plant are $95.10 and $62.10 with coal at $5 and $2 a ton respectively. The costs for intermediate sizes and prices of coal, of course, lie between these limits. The author believes that there is no question as to the cheapness of hydraulic power, as he has seen figures ranging from $3.38 to $6 per horse-power-year. The actual costs for hydroelectric power varies with the distance the current is transmitted; but they may be taken practically as $10.16 in the immediate vicinity of a waterfall, $11.66 with a four-mile transmission and $12.81 with a twenty-mile transmission. Hydropneumatic power is the only serious competitor of hydroelectric power within a twenty-mile radius of the power plant; beyond that electricity would always win. With very small plants undoubtedly gasolene would compete successfully with electricity, as it would not pay to develop water power so small. Too much can not be said with regard to proper development of hydroelectric plants within the period of ten or fifteen years as too short to study the monthly and annual precipitation of a good drainage area. His records show that the marked variations covering periods of thirty and even forty years occur in the rainfall. Mr Webber does not agree with Mr. von Schon that hydroelectric developments should always be based on some stage between a low and normal flow, as it has always been found preferable to carry on the development at some stage between the normal and high fall of the watershed. This can be determined only on local costs of auxiliary power, but can usually be taken up to the average fall of the ninth month in the order of dryness. Figures are shown of the actual cost of the various items of a ten and a sixty-horse-power steam plant. The former cost complete $2,368, the latter $11,978.—*Abstracted from the Engineering Magazine (New York), September.*

The Size, Weights and Cost of Alternators, as Affected by Rated Speed and Periodicity.

Believing that it is not generally realized by central-station engineers to what degrees the size, weights and initial costs of alternators are affected by the speed for running and periodicity to which the machines are to operate, W. Chappell and T. Germann endeavor here to point out some of these differences. In order to do this, alternators were designed of 400, 600 and 1,000 kilovolt-amperes output, and of each output, for 100 revolutions per minute, fifty cycles and 300 revolutions per minute, twenty-five cycles, these being strictly commercial figures. The designs of these machines are given. In examining them the first point to be considered is the number of poles which are required. With a slow-speed machine such as that for 100 revolutions, sixty poles are required to get fifty cycles; whereas at 300 revolutions only ten poles are required, one-half the periodicity. Thus, in the first place, in order to accommodate the poles the armature of the slow-speed machine must be larger in diameter than that of the other, although the gross core length will be less. This brings up the question of what are the disadvantages of slow-speed machines as compared with high speed. In the first place, a deeper pit and heavier foundations are required for the former, also the initial cost is greater. Greater head room is required, and in order that the switchboard attendant should have an uninterrupted view of the gallery, the switchboard gallery must be higher, which means a higher building. Taking up the machines, it is shown that, although in every case the highest speed machine has a lower active diameter, yet it has a greater core length. It would seem at first that at high speeds the weight of the armature should be lower; but this does not follow, for a comparison of the diameters of the six machines designed shows that for the slow-speed machines the active materials of the armatures are in every case actually lower than that for the high speed, the increase in weight of active material of the slow-speed machine being due to the field. The weight of armature copper is greater though, as the armature copper loss increases with the decrease of speed due to the increased total length of conductor. This is also the case with the field copper. Turning to the field, it is found that that for the low speed is the heaviest, as would be expected, owing to its having sixty poles as against ten poles in the higher speed. A comparison of the weights of the various designs shows that both the iron and copper are double the weight for the slow speed that they are for the high-speed machine. This more than makes up for the thirty per cent to forty per cent decrease in the weight of the active armature material. To the weights of active material, however, must be added the weights of inactive material, such as shafting, spiders, supports and armature laminations. In the lower-speed machines the large diameters necessitate heavy spiders which add considerably to the weight, and also require heavy supports for the stationary armatures. Allowing for these, it is found that the total weights per kilovolt-ampere are as follows: For a 400-kilovolt-ampere, 300-revolutions-per-minute, twenty-five-cycle machine, 48.1 kilogrammes; for a 400-kilovolt-ampere, 100-revolutions-per-minute, fifty-cycle machine, the corresponding figure is 105 kilogrammes; for a 600-kilovolt-ampere, 300-revolutions-per-minute, twenty-five-cycle machine, and a 600-kilovolt-ampere, 100-revolutions-per-minute, sixty-cycle machine, the corresponding figures are 48.1 and 122 kilogrammes per kilovolt-ampere; for a 1,000-kilovolt-ampere, 300-revolutions-per-minute, twenty-five-cycle, and a 1,000-kilovolt-ampere, 100-revolutions-per-minute, fifty-cycle machine, the figures are respectively 35.1 and 78.4.—*Abstracted from Electrical Engineering (London), August 22.*

Methods of Getting New Business

A DEPARTMENT DEVOTED to the COMMERCIAL DEVELOPMENT of CENTRAL STATIONS

Managers are Invited to Contribute Suggestions for Methods of Increasing the Demand for Electric Service

EDITED BY CHARLES A. PARKER.

The Electric Arc versus the Gas Lamp.

BY E. A. CREED.

(Continued from August 10 Issue)

The gas lamp is an open-flame burner. Many serious fires can be traced to its source.

At fourteen cents per kilowatt-hour, the electric incandescent lamp is cheap. Each sixteen-candle-power lamp costs about three-fourths of a cent per hour to burn.

The rate in Providence is not high. The writer was in the employ of a company, operating a hydroelectric plant, that charged twenty cents per kilowatt-hour. The writer has been connected with a large corporation that controlled many electric light companies. In the town of A, we charged a rate of five cents per kilowatt-hour. We were losing money on our lighting consumers at that rate.

In the town of B, we charged twelve and one-half cents per kilowatt-hour. We had more kicks coming from the people of A on exorbitant bills than from the twelve and one-half-cent town of B.

By carefully calibrating the respective meters in use in each town, we found that we were two per cent "to the bad" in A, while in B we were three per cent "to the good."

Whenever a man complains that his bills are high, his service poor, that the company robs him, etc., try to show him that it is to the company's interest to treat its customers fairly, that it would be a case of standing in its own light were it to do otherwise. Offer to have the meter investigated at once; do all in your power to please him.

He'll be absolutely without a fair argument; but remember it takes two to make a quarrel and if you leave him with promises of early attention to his complaint, nine times out of ten he'll forget he ever had a kick to register.

All artificial illuminants must permit of continued use without any bad effect upon the health. Such deleterious effect usually arise from the products of combustion vitiating the atmosphere, or possibly from injury to sight.

Gentlemen, did you ever attempt to read under the light from a gas lamp? Try it. You'll never forget it. Drive this home to your prospects. Show how the lamp flickers, how trying this flicker is on the eyes.

For the few miserable pennies a man may save by using the gas lamp, he will lose dollars to the oculist for treatment upon the eyes.

The light of the gas lamp is accompanied by intense heat; the electric incandescent radiates but little heat.

Every cubic foot of ordinary commercial gas requires for its combustion the oxygen from about twenty feet of air, so that a burner consuming five cubic feet per hour combines with the oxygen of about 100 feet of air per hour. Besides vitiating the air and raising its temperature by the heat given off, much more thorough ventilation is required.

In cases where night work is carried on, a highly heated, vitiated air has an injurious effect upon the eyes. Gentlemen, you know there are many insurance companies. They have their agents all over this broad land scouting around after more business. The competition among them is keen. Compared to selling insurance, selling electric current is like taking a bone from a dead pup.

You have no competition but a poor, lone gas lamp that in comparison with the electric arc is like unto a battery lamp at noontide.

Mr. Jones advises you that he is going to throw out the electric arcs. He's going to show the electric company that he's going to get along without them.

Tell him you are sorry, for aside from the loss of revenue, you would hate to see his store looking like the Mammoth Cave at midnight, or a mine shaft before the fire-boss opens up.

Ask him to come out with you and see for himself how different is the illumina-

Two photographs from Janesville, Wis., indicating that the Janesville Electric Light Company is not permitting the powers of darkness to make themselves felt very strongly in that city. Many of the large cities can gain a good deal of inspiration, and would do well to study the methods adopted in some of the smaller cities, especially those of the Janesville class, where the commercial department is of so high-grade and thoroughly effective a character. Mr. Korst, the manager of this plant, is a thorough believer in advertising and solicitation—none more so—and he is getting the results because he believes in them, and because he believes in doing them both right.

tion of Victor Gelb's interior from that of Hall & Lyons'.

Offer him the services of a competent engineer at the company's expense and get his promise to wait until you see him again before doing anything.

Then get your department head; after that, use your brains.

Just to
Remind You—
once more—that you're losing a great opportunity by not using an Electric Sign. An Electric Sign over your store keeps it in evidence for five hours longer each day.
COURTINN
BUFFALO GENERAL ELECTRIC CO.
CONTRACT DEPARTMENT
712 Fidelity Bldg

A novel mailing card sent out by the Buffalo General Electric Company to prospective electric sign users. It is a piece of advertising above the average in value.

Gentlemen, we are in a commercial age.

Ade, the slang philosopher, tells a story about his entrance into the newspaper profession.

He saw two desks, one a magnificent roll-top affair, the other a three-legged wreck, hacked and unstained. The roll-top was his if he cared to become the business manager; the wreck was for him who would an editor be. You see the plums go to the man who can sell.

Manufacture, or means of production; the railroad, or means of transportation; selling, or the means of distribution, are the three "its" in this commercial age.

Where are the bright, brilliant fellows? They are in the selling game. They are in Africa selling mining machinery; in South America selling locomotives; in Europe selling grain; in Providence selling electric current.

To whom does commerce offer her great prizes?

To the sellers—to the salesmen.

Why is it that one company handling the self-same product at the identical or lower price of a competitor will go to the wall, while its rival will go on forever? It's simply because one employs high-class salesmen.

The writer had this fact brought home to him rather forcibly the other day. In the course of conversation with a prospect, it was mentioned how great a difference there was among salesmen. The merchant stated that he bought goods from a certain firm solely on account of the salesman. "He never gets fresh," said the gentleman; "he doesn't jolly the stenographer. He always minds his own business and never criticizes me or my goods, while (mentioning a name) tells me I am way behind, etc."

So, gentlemen, let's get together, put our shoulders to the wheel and make up our minds that every electric arc is going to stay, that few gas lamps will go in, and that the electric lighting company has a commercial department that is one in fact and not fancy.

New Business Activities in Buffalo, N. Y.

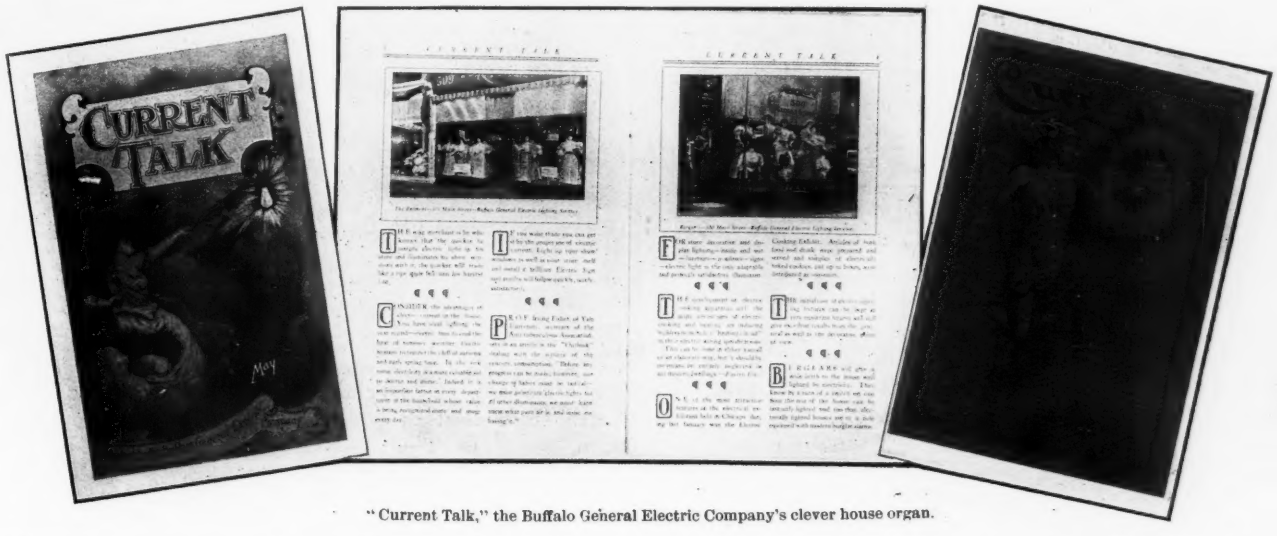
For several years more or less advertising has been done by the Buffalo General Electric Company with highly gratifying results, but it was not until the present year that a thoroughly well-organized and complete special advertising campaign was entered into.

One of the most effective features of this advertising campaign was specially prepared matter mailed to a large list of residences.

These advertisements were sent out every two weeks and are still continuing to be sent out in that way. This service consists of high grade direct-by-mail advertising, including booklets, folders, mailing cards, novelties and letters. The letters are in every case an excellent imitation of a genuine typewritten letter, with the names of the recipient filled in carefully on the typewriter.

Some of the booklets and special folders used have been unusually excellent, even for so high grade a service, and the results so far attained show that in advertising of this character it pays to use the best, the public being keen to appreciate and discern between the forceful and the mediocre.

Similarly high grade in character is the direct-by-mail advertising issued by this company in the interests of its power



"Current Talk," the Buffalo General Electric Company's clever house organ.

department. A list of users, and possible users of power, was compiled and checked over, and upon this list was turned a rapid-fire campaign of booklets, mailing cards, folders and letters, mailed every two weeks. While power business does not mature in a day or two, continual pounding, continual accumulating of interest on the part of the possible consumer, does bring results.

In commercial lighting two campaigns have been carried on; one for merchants

This excellent portrait of Ralph W. Richardson arrived too late to accompany the article covering the commercial work which has been done in Jackson, Tenn., under this gentleman's direction.

and business men, exploiting the value of electricity as an advertising medium, lighting of show-windows, showcases, outline lighting and interior lighting; the other devoted to electric signs.

The first-named campaign is a particularly well-conceived rapid-fire follow-up, carrying throughout the idea of the advertising value of electric light.

In every piece of literature the merchant is confronted with the uncombatable argument that whatever earns money is not an expense but an investment, and is asked to look upon the cost of electrically lighting store and show-windows as a purely business proposition, in which the returns will be as sure and satisfactory as would be his investment of the same amount of money in a high-grade salesman of the human type.

This idea is brought out cleverly in many of the pieces, and the merchant receiving this series of literature can not fail to be impressed with the strength and truth of the arguments contained therein.

Many of the illustrations which adorn the folders and booklets are apt and convincing. For instance, there is one showing a number of stores brightly illuminated with electric light, across which are written the words "How About Sunset to Midnight?" This design forms the outside of the folder and may be said to get the merchant thinking along the right direction, while on the inside is a large dial or clock face showing the hours from six until twelve illuminated by electric lights, while the merchant and his clerks are leaving the store at six o'clock, and the reading matter suggests that he can go on selling after he and his clerks have gone home, if he will put on electric light as his evening salesman.

The service is made to be very timely and seasonable; for instance, during the hot months of the summer several pieces of the advertising were largely devoted to the use of fans in business places.

One very clever idea along this line was a mailing card entitled "As Cool as a Cucumber," which was cut out to represent the shape of a cucumber and the coloring and general appearance of the card was exactly a facsimile cucumber.

In the sign campaign used by this company will be found some of the best arguments in favor of electric signs that have ever been advanced by any central station, and the clever designs and illustrations which have accompanied many of these talks have given point and effectiveness to the whole campaign in a most thoroughly excellent manner.

Besides this twice-a-month cannonade of advertising in the four principal departments of activity, there is also sent out to a special list, consisting principally of merchants and business men, an excellent monthly bulletin entitled "Current Talk," which is devoted largely to timely write-ups of electrical subjects, and also to reporting installations of electric light and power which the company has recently made in and around Buffalo.

These reports or write-ups of electrical installations are, as a rule, accompanied by excellent reproductions of photographs made at night, all of which tends to please the customer who finds such notice given to his store or business place, and also attracts the notice of other merchants in his vicinity, who are by this means encouraged to do likewise, and thus receive a similar tribute.

Of course, all this advertising has not been done and left to stand on its own footing, as a means of business-getting. On the contrary, a very strong corps of solicitors has been at work thoroughly cultivating the field while this seed of advertising has been sown.

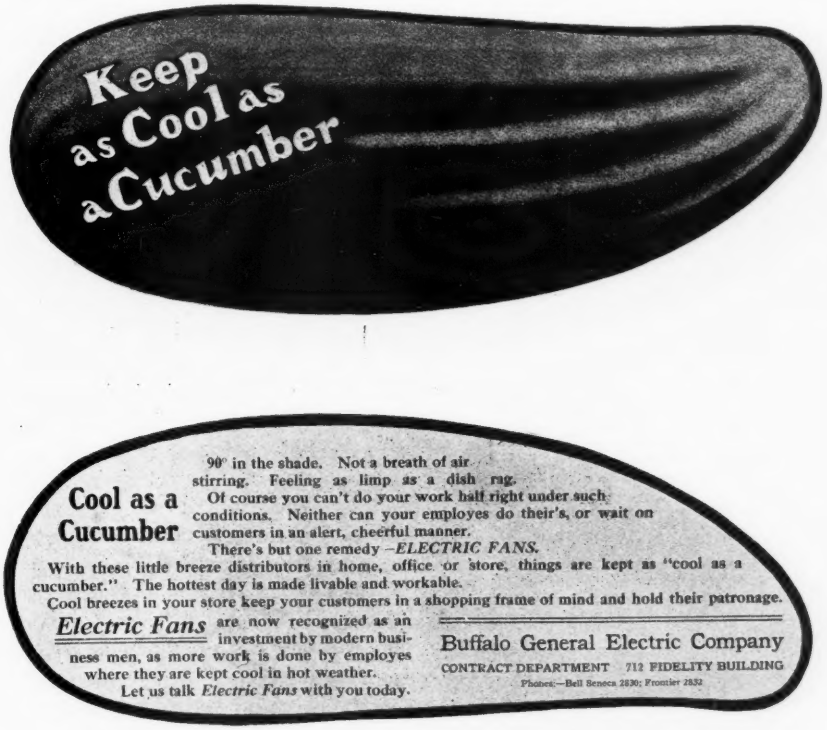
Here is a well-designed, well-written and well-printed booklet employed by the Buffalo General Electric Company in soliciting store and window lighting.

Some Buffalo Newspaper Advertisements.

An excellent system is in force which insures that the moment a party is heard from, either by telephone, return postal card, or in any other way, a representative hastens to see him or her, thus striking while the iron is hot and making certain that the largest possible number of interested people are closed for contracts.

There is the greatest possible degree of harmony and good fellowship existing between the advertising department, which is under the direction of George W. Ames,

and the soliciting department, with the result that every solicitor feels and knows that the advertising which is being done is in no way conflicting or competing with his individual efforts, but is the strong cooperative backing of the company in-


Keep as Cool as a Cucumber
Cool as a Cucumber
90° in the shade. Not a breath of air stirring. Feeling as limp as a dish rag. Of course you can't do your work half right under such conditions. Neither can your employes do their's, or wait on customers in an alert, cheerful manner.
There's but one remedy —ELECTRIC FANS.
With these little breeze distributors in home, office or store, things are kept as "cool as a cucumber." The hottest day is made livable and workable.
Cool breezes in your store keep your customers in a shopping frame of mind and hold their patronage.
Electric Fans are now recognized as an investment by modern business men, as more work is done by employes where they are kept cool in hot weather.
Let us talk Electric Fans with you today.
Buffalo General Electric Company
CONTRACT DEPARTMENT 712 FIDELITY BUILDING
Phones:—Bell Seneca 2830; Frontier 2832

A unique and suggestive mailing card used by the Buffalo General Electric Company to popularize the electric fan. The card is richly suggestive of the cool, refreshing looks of a cucumber, as well as of the cooling breezes of an electric fan.

tended to make his own individual efforts as resultful and profitable as possible.

The system adopted by the Buffalo General Electric Company along this line is one which every company in the larger class of cities ought to adopt, and that is to keep every employé in close touch with what the company's plans for advertising are. This is done in the case of the Buffalo General Electric Company by means of a monthly letter which is sent out by William Huntley, assistant general manager of the company, in which he tells his force about the efforts the company is making along certain directions, asks their continued cooperation, and asks them also to make a study of the advertising which the company is doing and which in every case is sent to the house address of each employé.

In this way, a solicitor who perhaps is working entirely on signs, still keeps in touch with the advertising which is being done for power business, and, as is often very likely to occur, if he runs across somebody who is interested in the power proposition during the course of his visitations, he will be sufficiently interested to see that the man's name is added to the power list to receive the power advertising, and also will instruct the power representative to call upon him, usually making an appointment for him.

This is a most excellent method and works out especially well because it makes the employés of the company feel that they are being, to a certain extent, taken into the confidence of the company by being asked to make suggestions and to study the advertising methods and announcements of the company.

A department of the company's commercial activity which is also closely watched and carefully superintended is the newspaper advertising. Ten-inch advertisements are run three times per week in all the principal dailies. These advertisements cover principally the residence field, as is, of course, proper in the case of newspaper advertising, it being obviously a waste of good money to devote very much newspaper advertising to the power end of the business, when the large circulation for which you are paying is composed of ninety-nine men who are not interested in power, for every one which you will find in that circulation who is interested in power.

Mr. Huntley states that the new-business department is showing highly gratifying results, and any central station man while in the neighborhood of Buffalo should call at the office of the Buffalo General Electric Company, and look over the excellent organization and up-to-date methods that Mr. Huntley has successfully put in force.

The Wheels of Industry
The Wheels of Industry
ELECTRICITY with individual motor equipment is the modern method of turning the wheels of industry.
No matter how much or how little power may be required, experience has time and again demonstrated that the substitution of an electrical system of driving machinery will not only increase the output and furnish more convenient, safe and reliable power, but will permit of economies before undreamed of.
In flexibility, electric power is tremendously superior to any other form of driving energy.
By its use you would enjoy lessened fire risk, more room, greater accessibility, increased light, greater convenience in handling goods and an all round increase in capacity.
Electric Power is always ready at any hour of the day or night.
A touch of the switch starts the power when you need it; another touch shuts it off when you are done.
You pay only for power that has done work for you.
Get that conviction out of your mind that electric power is expensive! Remember that the unreliable, dirty, noisy, wasteful prime-movers have not even the quality of economy to recommend them.
The truth is that electric power is the cheapest motive force that can be used to drive the wheels of any industry.
Let us figure on YOUR power problems. Our power expert is at your disposal.
He will be glad to give you plans and suggestions.
Simply mail us the enclosed postal.
Buffalo General Electric Company
CONTRACT DEPARTMENT
711 FIDELITY BUILDING
Phones: Frontier 2833; Bell Seneca 2830

An unusually strong folder of the Buffalo General Electric Company which talks in an argumentative way upon points which will affect the most influence with dealers. Every power user will be sure to look at it and read it.

INDUSTRIAL SECTION

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS

The New Lamp Factory of the Brilliant Electric Company.

Excellent progress is being made upon the new lamp factory of the Brilliant Electric Company, which is now in course of construction at Conneaut, Ohio. This lamp manufactory has been designed by one of the most prominent architects in Cleveland, Ohio, and is being constructed under the specifications of the engineering department of the National Electric Lamp Association. Every possible point of advantage to enable the lamp-makers to produce a perfect incandescent lamp has been considered, and it is the opinion of many lamp experts who have visited the Conneaut building that the construction is ideal and that incandescent lamps will be produced with the least possible handling and under the most advantageous methods of inspection.

The plant will be in full operation about October 1. In addition to its ideal construction the equipment will be entirely of new machinery, and will include the latest mechanical improvements in lamp-producing apparatus. The factory will have an initial capacity of about 5,000,000 lamps per annum, and the output can be materially increased as the demand justifies it. The Brilliant Electric Company owns ground adjoining the factory, so that enlargements can be made as may be found necessary.

E. J. Kulas, secretary and general manager of the company, in a recent interview, stated that no expense had been spared in building the factory and equipping it, and that at all times the company will be glad to welcome its customers and friends and have them inspect its facilities for manufacturing incandescent lamps. The superintendent of the factory will be H. F. Schaedel, who is recognized as one of the most competent lamp-makers in the country.

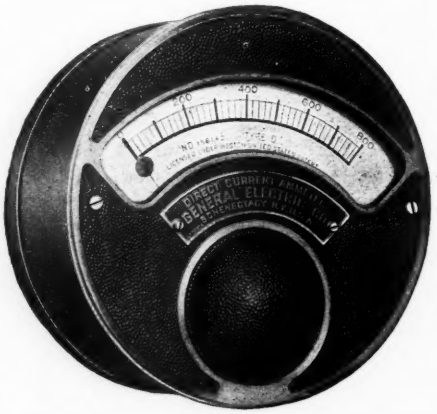
Mexican Light and Power Company.

The Mexican Light and Power Company has authorized an issue of $2,400,000 of preferred stock, with which it is proposed to pay off loans advanced by banks and purchase the only other lighting plant in Mexico.

New General Electric Instruments.

A new line of ammeters and voltmeters for direct-current switchboard use has been placed in production by the General Electric Company, Schenectady, N. Y.

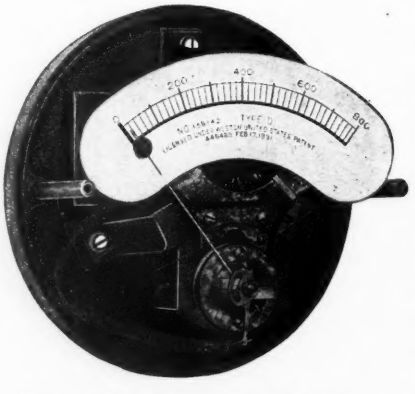
These instruments, which are to be known as type D, are constructed on the



EXTERIOR VIEW, NEW G. E. DIRECT-CURRENT AMMETER.

D'Arsonval principle. A small coil of wire mounted on a light cylindrical aluminum frame is pivoted in jeweled bearings so as to move freely in a small annular space between a soft iron core and the pole pieces of a permanent magnet.

The operation of these instruments is rendered dead beat by the Foucault currents generated in the aluminum frame



INTERIOR VIEW, NEW G. E. AMMETER.

as it passes through the field of the permanent magnet. This damping quality prevents injury to the pointer from violent load fluctuations and permits rapid and accurate readings as the pointer comes quickly to rest after each change in current value.

Continued accuracy of type D instruments is assured by the unusually high torque, light moving elements and the very small air-gap between magnet pole faces and the iron core combined with the permanency of the magnets, which are made from the best obtainable grade of magnet steel and subjected to special processes of hardening and aging which fixes its magnetic characteristics.

The round cast-iron case which encloses the instruments protects it from the effects of stray fields and makes it dust-proof.

Inspection or repairs of type D instruments is easily made. The soft iron core, together with the armature and jewel supports, are assembled within the soft steel shell constituting the pole pieces. By removing the screws which hold the shell to the magnet pole faces, the entire mechanism may be removed.

The scales of type D instruments are uniform throughout their entire range and very legible. The standard finish is dull black with raised portions polished copper, making a very pleasing and durable surface.

Type D voltmeters are made self-contained in capacities up to and including 750 volts. The ammeters are self-contained up to sixty amperes capacity. Larger capacities are furnished with external shunts, which are made of a special alloy having practically a zero-temperature coefficient. All instrument shunts above 1,000-ampere capacity are now provided with a thermoelectric attachment. This attachment consists of a metal strip having one end electrically connected with one end of the shunt, with the other end in close thermal contact with the other end of the shunt but insulated from it electrically. The ammeter leads are connected to the shunt and to the metal strip at the two insulated points. This prevents the superimposing of secondary thermoelectric currents upon the primary current, which is due to the fall of potential in the shunt and the amount of which fixes the value of the indication of the instrument. Ammeter shunts with this attachment will be found free from temperature errors due to generation of thermoelectric current.

Some New Jandus Specialties.

The accompanying illustrations show some specialties which the Jandus Electric Company, Cleveland, Ohio, has recently placed on the market. Fig. 1 shows the Jandus patented pull switch ready for use. This switch represents the latest ideas for arc-lamp control. The switch may be incorporated with the lamp extension, or it may be introduced into the suspension chain, as preferred. The controlling chain may be made of any length desired, and arranged within convenient reach of the operator. The mechanism of the switch, including the chain, is easily removable, and employs an approved and standard quick-break switch.

Fig. 2 shows the Jandus interchangeable arc lamp equipped with a side-wall reflector. In this arc lamp a single logical structure is provided, which may be adapted for any department of arc lighting. The main or common structure of this lamp, with the casing and globes, constitutes a complete arc lamp with the exception of the regulating mechanism. It is so designed that mechanisms adapted for the several kinds of circuits may be placed in and secured to the structure without taking the latter apart. The common structure consists of the hood, which carries the switch; the centre tube, removably attached to the hood and carrying at its lower end the expansion and diffusion chamber, the floor plate, the globe cap, the lower carbon-holder and inner carbon-holder. The clutch is part of the common structure, and also the bell-mouthed sheath and cable carried in the centre tube. The casing is a part of the common structure, since it is identical for all the lamps.

FIG. 1.—JANDUS PATENTED PULL SWITCH READY FOR INSTALLATION.

The multiple lamps comprise lamps for the following circuits: direct-current, 100 to 125 volts; direct-current, 200 to 250 volts; alternating-current, 100 to 120 volts, sixty cycles; alternating-current, 100 to 120 volts, 125 to 140 cycles. The lamp-regulating mechanisms for the above circuits are quickly interchangeable. A change from 110 volts, direct current, to 220 or 250 volts, direct current, involves simply the substitution of a differing actuating mechanism and a different size and length of resistance wire, the porcelain base for supporting these devices being common to both. To change from 250 volts, direct current, to 110 volts, direct current, it is only necessary to change the magnet spools and the resistance wire. To change from direct current to alternating current the rheostat is removed from the lamp and a reactance coil inserted in the same place. One mechanism is unclamped from the central stem and the other substituted. These changes are made without disturbing or taking apart any other portion of the lamp.

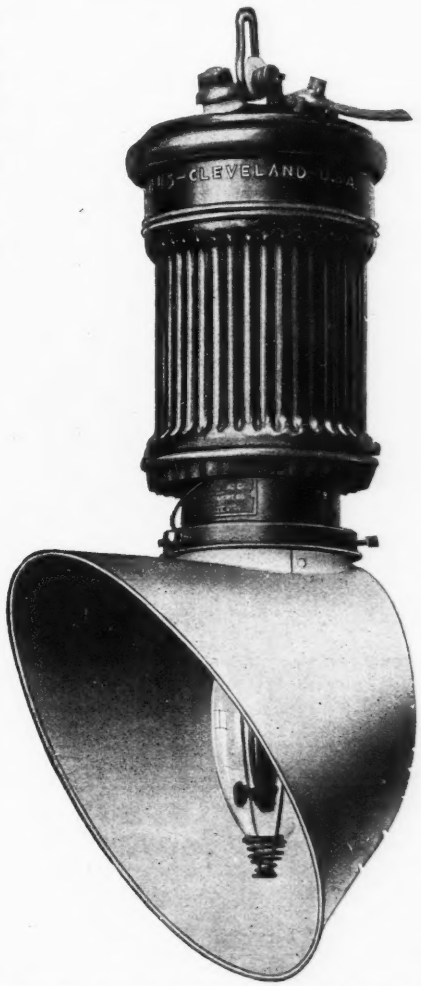


FIG. 2.—JANDUS INTERCHANGEABLE ARC LAMP EQUIPPED WITH SIDE-WALL REFLECTOR.

The New Plant of the Novelty Incandescent Lamp Company, Emporium, Pa.

The additions which have been under construction for the factory of the Novelty Incandescent Lamp Company at Emporium, Pa., are now practically complete. By their accomplishments, this company has a substantial plant of brick 101 by 80 feet, two stories in height. The factory is located directly adjacent to the tracks of the Pennsylvania Railroad. In this plant has been established a complete machine shop, in which has been constructed its own pumps, sealing machines, treaters and other lamp-making machines for use in its factories.

The entire building has been constructed and equipped under the direct supervision of the president, Mr. R. K. Mickey. It has been his idea to accomplish a manufacturing establishment which would rank high as embodying modern ideas enabling economy, speed and accuracy in the making of its product.

President Mickey announces that each department of the process in lamp making will be in charge of a competent foreman or forewoman, and that a highly developed system of inspection will prevail throughout the entire plant. This Emporium plant is known as "plant No. 2," as the company operates a plant at St. Marys, Pa., which is known as "plant No. 1." President Mickey states that the "capacity of the Emporium plant will be brought to 7,000 new incandescent lamps daily before the end of September, and that only new lamps which are designated as Elk lamps, Class A, are manufactured at Emporium. These lamps are made in all candle-powers, voltages, efficiencies, bases and shapes."

It is the announced purpose of this company to carry 100,000 lamps constantly in stock, enabling prompt shipments to buyers. The plant at St. Marys, however, is entirely used for refilled lamps, which latter lamps are known as "XL Refilled Lamps."

This company maintains agencies with stock in Chicago, St. Louis, Cincinnati, Cleveland, Pittsburg, Buffalo, Syracuse, New York, Boston, Atlanta and Birmingham, Ala.

The Fort Wayne Series Alternating-Current Arc Lamp.

The Fort Wayne Electric Works, Fort Wayne, Ind., has designed the Form C alternating-current series arc lamp shown in the accompanying illustrations, one to operate on sixty-cycle circuits, and the other to operate on circuits of frequencies varying from 125 to 140 cycles. The appearance of the lamp from the outside is quite similar to that of the multiple-type alternating-current arc lamp, and the direct-current series lamp which has been so successfully manufactured by the Fort Wayne Electric Works. The hood from which the whole mechanism is supported is rigidly constructed of cast iron. The lamp is supported by means of a malleable-iron link enclosing a porcelain insulator attached to the top of the hood. This link is designed in such a way that it always remains in a vertical position, so as to be easily attached to the suspension hook. Upon the outside of the hood are supported the two terminals, by means of which current is supplied to the lamp. The handle for operating the short-circuiting switch is also in a convenient position upon the hood. The protecting case is made cylindrical in form, from heavy sheet copper lapped together in a single riveted and soldered joint. The case is removed by releasing two bayonet catches.

The globe-holders adopted for these lamps are designed with a light-weight spring upon each set screw which holds the globe. This design provides for any unequal expansion which may take place between the globe and the holder. Reflectors may be furnished, which are attached to the lower edge of the case, without in any way affecting the design of the latter.

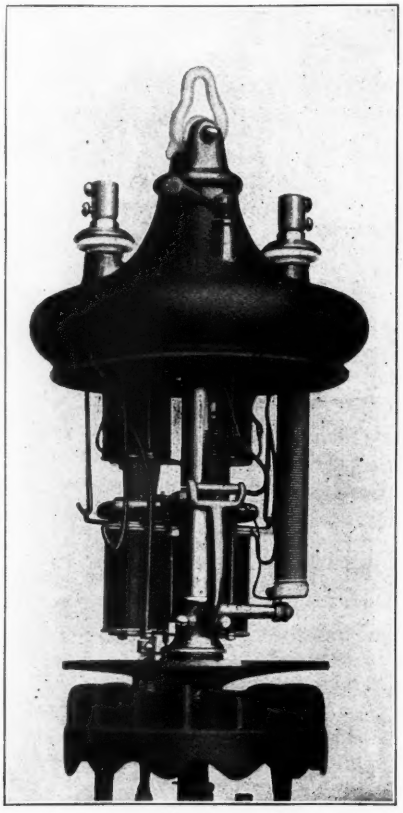
The mechanism of both the sixty-cycle and 140-cycle lamps, together with the radiator, gas cap and lower carbon-holder, is supported from the hood of the lamp by means of a central brass carbon tube.

The lamp is of the differential type, employing both series and shunt magnets in the form of solenoids, with a single laminated armature in the form of a letter H.

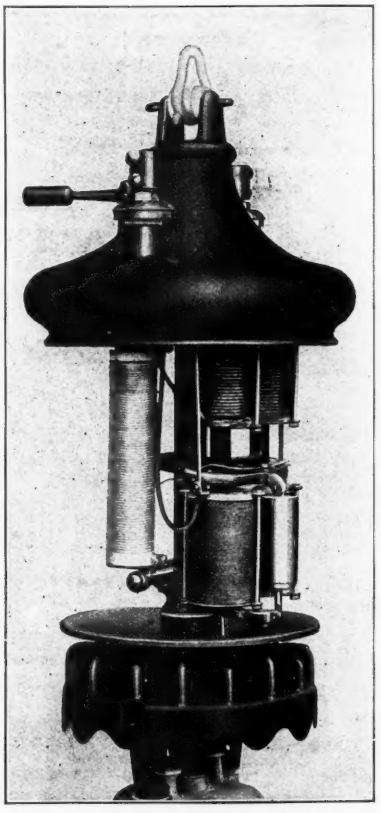
Series magnets are hung directly over the shunt magnets, the axis of each series spool coinciding with that of the shunt spool directly below. One leg of the branched armature moves freely in a vertical path within each magnet spool, the whole armature being supported by a lever which, in turn, operates the carbon clutch of the lamp. This lever floats about its fulcrum under force given it by the magnets at one end, balanced by an adjusting spring at the other. By changing the tension of this spring, the length of the arc may be adjusted. A dashpot is provided upon the armature lever, hung in such a manner as to make all regulating movements dead-beat and noiseless.

The relighter coil of this lamp is supported between the hood and the lower frame of the lamp, and consists of a coil of resistance wire wound on an asbestos-covered tube. This relighter resistance automatically shunts the series magnets and carbons in case of an excessive increase in voltage across the arc. One end of the relighter resistance is permanently connected to one terminal of the lamp, while the other is flexibly connected to a phosphor-bronze contact mounted upon the lever arm mentioned above, but completely insulated therefrom. In close proximity to this contact, and mounted upon the movable armature of the magnet, is another phosphor-bronze contact electrically connected to the other terminal of the lamp by means of a flexible lead. These two contacts are located in such

FORT WAYNE FORM C SERIES ALTERNATING-CURRENT ARC LAMP.



DETAILS OF FORT WAYNE SIXTY-CYCLE LAMP.



DETAILS OF FORT WAYNE 140-CYCLE LAMP.

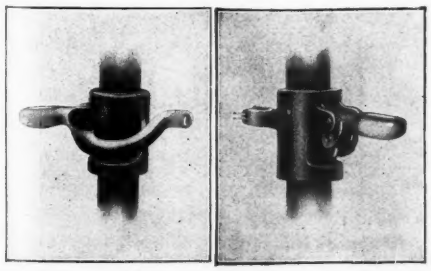
manner that they touch each other as soon as the shunt magnet becomes materially stronger than the series magnet.

When the relighter coil is connected into

Details of Gas Cap and Carbon-Holder.

the circuit, a sufficient drop of potential is maintained across its terminals to permit the series magnets to operate properly should the carbons again be brought together.

The upper carbon slides within the carbon tube, and collects current from the latter by means of a trolley. The trolley forms a part of the upper carbon-holder, and consists of four phosphor-bronze contact springs mounted with their edges bearing upon the inside surface of the



Clutch, Showing Tripping Lever and Shoe Sides, Respectively.

carbon tube and making electrical contact with it. The carbon shoe clutch is constructed so that all wear may be easily taken up without taking the clutch apart or removing it from the lamp. The clutch completely surrounds the upper carbon, gripping it by means of a series of teeth which bear upon its surface only as the armature of the magnets above it rises. This gripping of the teeth upon the carbons is accomplished by means of a small lever pivoted upon the clutch casting and actuated by a light rod upon the mechanism above.

Some Tregoning Specialties.

The accompanying illustrations show two devices placed on the market by the Tregoning Electric Manufacturing Company, Cleveland, Ohio. Fig. 1 shows the Tregoning sign receptacle. This is of simple construction with few parts, and

Fig. 1.—Tregoning Sign Receptacle.

makes the replacing of the shell an easy matter, doing away with retaining screws and small nuts. An important feature embodied in this receptacle is the introduction of mica, insulating the two opposite poles on the inside of the receptacle. The small porcelain projections protect the terminal plates from coming in contact with the sign casing, eliminating the possibility of grounding or short-circuiting.

Fig. 2 shows the company's "Lobster-

Fig. 2.—"Lobster-Claw" Battery Connector.

Claw" battery connector. This device is claimed to positively and effectually prevent loose battery connections, and eliminates thumb nuts on the binding-posts. It is stated that the connection can not be affected by vibration, and the contact remains unbroken at all times. It is attached by simply compressing the springs, which are made of high-grade phosphor bronze.

General Incandescent Lamp Company, Cleveland, Ohio.

The beginning of this company dates back to 1885, when the manufacture of incandescent lamps for electric lighting was started in the city of Cleveland, Ohio, at a little factory on East Prospect street. These electric lamps were manufactured under the Swan patents of New Castle, England.

About 1890 the Adams-Bagnall Electric Company bought the Swan incandescent lamp business, and with the assistance of many of the old employés of the Swan company still manufactured incandescent lamps at the same address, except that it was necessary, in order to take care of the increased business, to enlarge the factory.

In 1897 the Fort Wayne Lamp Company purchased from the Adams-Bagnall Electric Company the incandescent lamp part of its business and many changes were made in the building and machinery used at the East Prospect street factory.

The next year, 1898, the name was changed to the General Incandescent Lamp Company, and trade-mark "G. I." registered. At this time there was a general overhauling of the factory at East Prospect street, it was greatly enlarged and improved, and an engineering department was added, and about this time the G. I. sales reached the million-per-annum mark. About this time the General Incandescent Arc Light Company, of 529 East Thirty-fourth street, New York city, made arrangements with the General Incandescent Lamp Company to take the entire product of the factory, and this continued until 1904, when the General Incandescent Arc Light Company consolidated with the Stanley Electric Manufacturing Company, of Pittsfield, Mass., which continued as the selling agents for the entire G. I. product until January 1 of this year, when the General Incandescent Lamp Company drew away from all other affiliated interests and opened a sales department at Cleveland, Ohio, in

connection with the factory where it is at present doing business.

Joseph Insull is the president of the General Incandescent Lamp Company, but the business is actively conducted by H. C. Rice, vice-president. Mr. Rice has looked out for the General Incandescent interests since 1904, when the G. I. Arc Light Company first took over the G. I. lamps. H. A. Tremaine is secretary and treasurer.

In this age of progress, it is necessary, in order to be considered competitors at all in the lighting field, to keep abreast of those. This the General Incandescent Lamp Company has tried to do by establishing a fully equipped engineering department, where a corps of illuminating engineers are at the disposal of the business at all times free of all expense. Today the General Incandescent Lamp Company enjoys the distinction of having the largest single installation of the new metallized filament of its kind in the world. This is the new Pearce office building, St. Louis, and the installation numbers 7,614 lamps. After four months of telephone battery miniature lamps.

The company manufactures a full line of carbon lamps as well as Gem, tantalum and tungsten, as well as a full line of telephone battery miniature lamps.

The "Linolite" System of Lighting.

The accompanying illustrations show some of the features of the "Linolite" system of lighting, which is being introduced in this country by the Linolite Company of America. The inventor of the system, A. W. Beuttel, is devoting his attention to the manufacturing end, and the selling end is being handled by the H. W. Johns-Manville Company, 100 William street, New York city, sole selling agents. The "Linolite" system is already used extensively in Europe. The system takes its name from its principal characteristic, which is a line of light. This line of light is formed by placing end to end a series of tubular glow lamps running from one end of the tube to the other. Fig. 1 shows a section made up of these tubes. The filament, instead of being suspended from a stem, as in the ordinary bulb lamp, is stretched entirely through the tube, a loop being placed in the centre for taking care of the expansion and contraction of the filaments. The caps at each end of the straight glass tube have a central contact. The reflector is made from sheet metal, usually aluminum, and the holders are kept in position by means of a tubular head turned on each edge of the reflector. The reflector is two and one-quarter inches wide, and the entire fitting may be wholly or partly concealed behind the framework of a show window. The total depth of the fitting from the front of the lamp to the back of the reflector is one inch.

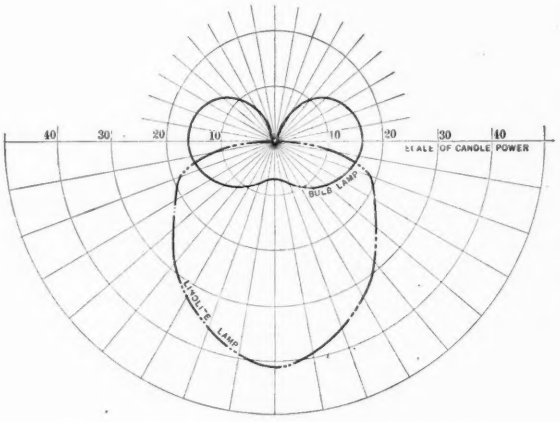


FIG. 3.—POLAR CURVES OF "LINOLITE" SYSTEM.

Fig. 2 shows a cross-section of the reflector, including a view of the porcelain support for the brass end cap. Fig. 3 shows the polar curves of candle-power of a sixteen-candle-power bulb lamp and a section of sixteen-candle-power "Linolite" lamp units. Taking the mean horizontal candle-power of the "Linolite" section as sixteen candle-power, the reflector increases the effective candle-power 100 per cent over an angle of seventy degrees, and fifty per cent over an angle of 100 degrees.

While the "Linolite" system has been used principally for show-window lighting, it is now being worked up for adaptation to car lighting, theatre footlight illumination, residence and factory lighting, for the outlining of buildings, electric signs, desk lights and in other useful forms.

FIG. 1.—ILLUMINATING SECTION MADE UP WITH "LINOLITE" TUBES.

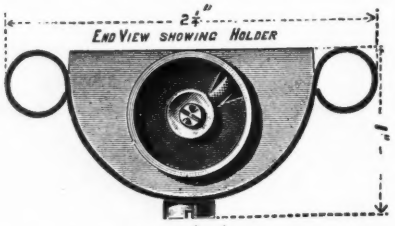


FIG. 2.—CROSS-SECTION OF REFLECTOR.

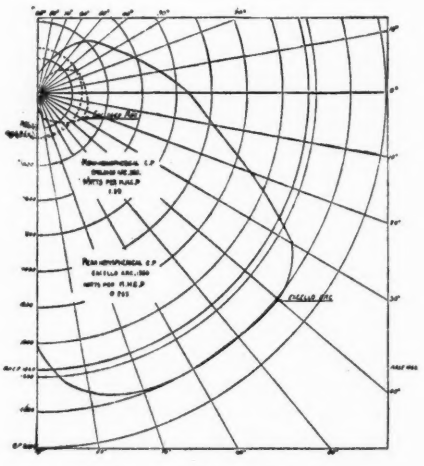


FIG. 1.—READINGS TAKEN THROUGH THE PLANE OF THE EXCELLO FLAME ARC.

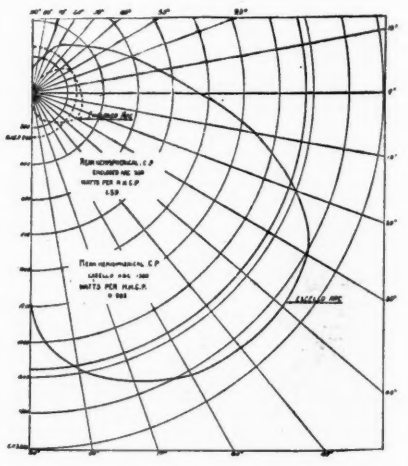


FIG. 2.—READINGS PERPENDICULAR TO THE PLANE OF THE EXCELLO FLAME ARC.

Candle-Power Curves Secured with Flame Arc Lamps.

The accompanying illustrations show two curves which have been secured, dem-

onstrating the mean hemispherical candle-power of an Excello arc lamp taking forty-five volts and eight amperes, manufactured by the Excello Arc Lamp Company, New York city. Fig. 1 illustrates the readings taken through the plane of the arc, and Fig. 2 shows the readings taken perpendicular to the plane of the arc. The tests were made on a Matthews arc lamp photometer, readings being taken only when the current and voltage were at their normal ratings—that is, within commercial limits. Each candle-power value is the mean of at least twenty independent readings.

The following table has been compiled from these tests, showing the distribution of luminous intensity:

Angle.	Candle-Power. Position No. 1. Max.	Ave.	Min.	Candle-Power. Position No. 2. Max.	Ave.	Min.
75° above	194	176	152	203	194	168
60° "	325	283	252	338	312	285
45° "	462	427	378	409	368	310
30° "	628	506	453	557	495	455
15° "	743	644	513	744	658	580
0° (horizontal)	976	879	731	1,097	954	842
15° below	1,535	1,191	877	1,643	1,432	1,250
30° "	1,849	1,692	1,443	2,061	1,815	1,663
45° "	2,117	1,800	1,500	2,122	1,882	1,634
60° "	2,120	1,797	1,560	1,811	1,336	1,559
75° "	1,909	1,768	1,646	1,793	1,656	1,317
90° "	1,493	1,436	1,388	1,368	1,151	961

Mean hemispherical candle-power, 1,560.
Watts per mean hemispherical candle-power, 0.265.

Position No. 1 indicates that the plane of the arc was in the plane of the mirror system—that is, the intensity was measured throughout a circle in the plane of the arc; while position No. 2 indicates that the intensity was measured throughout a circle in the plane perpendicular to that of the arc. The values given for the mean hemispherical candle-power were obtained from an analysis of computed values from the distribution curves and from direct measurements on the integrating photometer.

These tests were made with an eight-ampere lamp. However, ten amperes is now the standard amperage used with these lamps.

The X-Ray "Helmet" Reflector.

The National X-Ray Reflector Company, 245 East Jackson Boulevard, Chicago, Ill., has brought out a new reflector designated as the "Helmet." This reflector is especially designed to meet the requirements of lighting high and shallow windows. It is suited to the lighting of all windows over twelve feet high, where the depth of the window is less than one-half the height of the lamps above the bottom of the window, and is intended to produce an approximately uniform illumination over the goods as ordinarily placed in show-windows.

The reflector is designed to use a 125-watt Gem incandescent lamp. It will also take a 105-watt tungsten lamp. The external appearance of the reflector is shown in the accompanying illustration. It has one side partially flattened and extended down lower than the rest of the reflector. This flat side is placed next to and parallel with the window pane, and is designed to avoid, as far as possible, the wasting of light on the sidewalk. The reflector

FIG. 1.—THE "HELMET" REFLECTOR.

is unusually large, being about twelve and one-half inches in diameter and eleven and one-half inches high. This size was necessary to secure a high window illumination by catching as much light as possible and reflecting it in useful directions. Fig. 1 shows the "Helmet" reflector in a vertical position.

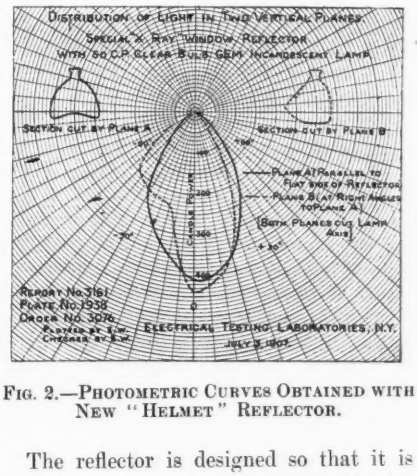

DISTRIBUTION OF LIGHT IN TWO VERTICAL PLANES
SPECIAL X-RAY WINDOW REFLECTOR
WITH 50 C.P. CLEAR B.L.S. GEM INCANDESCENT LAMP
SECTION CUT BY PLANE A
SECTION CUT BY PLANE B
PLANE A (PARALLEL TO FLAT SIDE OF REFLECTOR)
PLANE B (AT RIGHT ANGLES TO PLANE A)
(BOTH PLANES CUT LAMP AXIS)
REPORT No. 3161
PLATE No. 1938
ORDER No. 3076
PLOTTED BY E.W.
CHECKED BY E.W.
ELECTRICAL TESTING LABORATORIES, N.Y.
JULY 2, 1907.

FIG. 2.—PHOTOMETRIC CURVES OBTAINED WITH NEW "HELMET" REFLECTOR.

The reflector is designed so that it is practically impossible to improperly install it, as it is so constructed that the lamps point straight down. It is only necessary to install a row of wall sockets, pointing straight down, along the top of the window, and place the reflectors on the sockets, with their flat sides parallel with the window pane.

Fig. 2 shows photometric curves with the reflector equipped with a 125-watt clear-bulb Gem lamp, and held in position as used in practice with a standard three and one-quarter-inch holder. The lamp was placed in a position so that the plane parallel to the loops of the filament made an angle of forty-five degrees with the flat side of the reflector. In this figure the apparent candle-power at various angles in a plane at right angles to the flat side of the reflector is given, and also the apparent candle-power at various angles in a plane parallel to the flat side of the reflector is given.

The Just Tungsten Lamp.

The Just tungsten lamp is the invention of Dr. Alexander Just and Franz Hanaman, both of Budapest, Hungary. After years of labor they have succeeded in making a filament of tungsten which can be satisfactorily used for incandescent lighting. These lamps consume one watt per Hefner candle and burn on an average of 1,000 hours, with no apparent decrease in candle-power. They may be used on both alternating and direct-current circuits. The color of the light is a beautiful white. It is stated that although the filaments in these lamps are of very fine diameter, they can be shipped safely any distance. Both the Austrian and German factories are each turning out 10,000 lamps a day, and an English factory will soon be in operation.

The European factories at the present time are turning out lamps of twenty, thirty, forty, fifty and 100 candle-power for different voltages ranging from 100 to 120. Lamps are also made for 220 volts and fifty-candle-power. The lamps first mentioned are made with three filaments, and the 220-volt lamps with five filaments.

J. Auerbach, president of the Electrical Accessaries Company, New York city, represents the European syndicate in America. The Electrical Accessaries Company has been importing these lamps for the past six months, and has established sales in every part of the country.

The Germania Reflector Lamp.

The accompanying illustrations show some interesting results secured from photometric observations of the reflector lamp made by the Germania Electric Lamp Company, Newark, N. J. The use of reflector lamps for a good many purposes has been retarded because of the peeling of the enamel paint backing, which very often takes off the silvered surface afford-

ing the reflection with it. This has been overcome by the Germania Electric Lamp Company through its secret process of coating the silver with metallic copper which is little affected by the

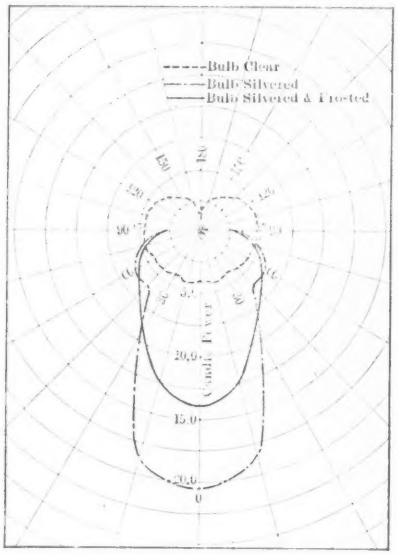


FIG. 1.—PHOTOMETRIC CURVE OF FOUR-CANDLE-POWER, TWENTY-WATT GERMANIA REFLECTOR LAMP.

heat as is the glass itself. A still further improvement is reached by a new method of silvering the globes, which gives an ideal reflecting surface. The company states that while this is a broad claim, it is more than substantiated by the diagrams showing the distribution of light from several of the types of reflector lamps which

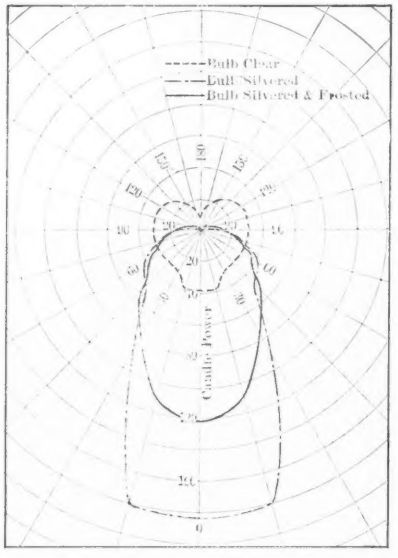


FIG. 2.—THIRTY-TWO CANDLE-POWER, 112-WATT GERMANIA REFLECTOR LAMP.

it makes. These diagrams are from tests made by the United States Bureau of Standards, the Electrical Testing Laboratories, of New York city, and elsewhere.

The Germania reflector lamps are made in four sizes, giving, respectively, twenty, thirty-five, seventy-five and 175 candle-power in a downward direction. The current consumption is the same as for regular four, eight, sixteen and thirty-two-candle-power lamps. Fig. 1, Fig. 2 and Fig. 3 show curves, respectively, for the four-candle-power, twenty-watt, thirty-

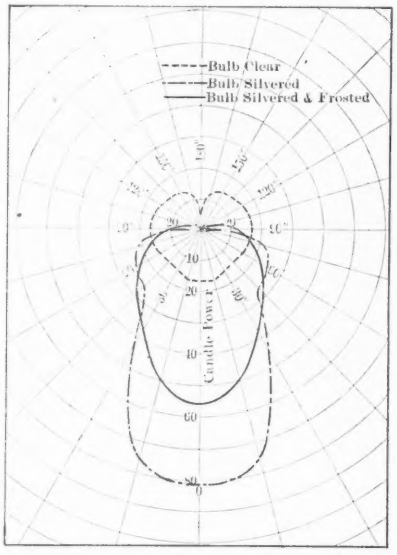


FIG. 3.—SIXTEEN-CANDLE-POWER, SIXTY-WATT GERMANIA REFLECTOR LAMP.

two-candle-power, 112-watt, and sixteen-candle-power, sixty-watt lamps. The dotted line is for the clear bulb, the broken line for the silvered bulb, and the solid line for the silvered and frosted bulb.

Suspension Type Insulator for High-Voltage Transmission Lines.

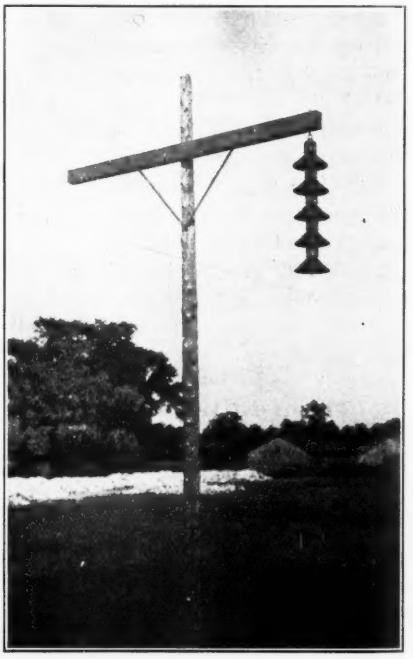
The Locke Insulator Manufacturing Company, Victor, N. Y., has designed and placed on the market a suspension type of insulator for high-voltage transmission. The accompanying illustrations give an idea of the appearance and adaptability of this type of insulator. The insulator element is made up of two pieces of porcelain—a short inner shell and an outer flaring shell. These shells are tested individually at a potential of approximately 60,000 volts before assembling, and the assembled element is tested at a potential in excess of 90,000 volts for a period of five minutes. The design of these insulators was developed by J. V. E. Duncan, electrical engineer for Sanderson & Porter, New York city, and W. T. Goddard, electrical engineer of the Locke Insulator Manufacturing Company.

This insulator possesses many advantages over the regulation pin-supported type of insulator for about 75,000 volts. It has great mechanical strength and can be made at a lower cost. The transmission line may be run with one unit, and the insulating element increased at nominal erection expense to at least 100,000

NEW SUSPENSION TYPE INSULATOR FOR HIGH-VOLTAGE TRANSMISSION.

volts, as the increase in the transmission voltage may determine.

In difficult localities one or more of the units can be carried about, thus taking advantage of the element of portability. The liability to puncture from damage is reduced because of the wider separation between the earth and the conductors. The



METHOD OF APPLYING NEW SUSPENSION TYPE HIGH-VOLTAGE INSULATORS.

insulator, being made up of a series of individual elements, it is extremely unlikely that the breakdown of one element will throw the line entirely out of service.

The insulator is said to have an ultimate mechanical strength ranging from 10,000 to 12,000 pounds.

Current Electrical News

DOMESTIC AND EXPORT.

NEW STREET CAR SYSTEM FOR CHIHUAHUA—Ten miles of rails for the transformation of the street-car system into an electric line and its extension to Nombre de Dios have arrived at Chihuahua, Mexico. Work will begin at once.

CHICAGO TELEPHONE LEASE AGREED UPON—It is understood that the arrangement between the Illinois Tunnel Company and the independent telephone interests, for the lease of the automatic service, has been decided upon, but the former company is awaiting the return of L. C. Krauthoff, attorney, from Europe. He will pass upon the legal phases of the contract before it is signed. No announcement as to the plans for the lease of the automatic telephone plant will be made public until all of these matters are closed up and the contracts are formally signed.

TRACTION COMPANY FILES MORTGAGE—The property of the Pacific Traction Company, of Tacoma, Wash., in King, Pierce and Thurston counties, has been mortgaged for $2,000,000, and the funds thus secured will be devoted to building new car lines in and about Tacoma. It is said that the company will branch out in the construction of an interurban network of trolley lines connecting the principal cities of the Sound region. At the present time the road has a line in operation from Tacoma to American Lake, fourteen miles distant. Numerous surveys for city lines have been made. A partial survey has also been made from American Lake to Olympia. E. J. Felt, of Tacoma, is the local head of the company.

ELECTRIC POWER IN MEXICO—The Compañia de Tranvias, Luz y Fuerza, of Guadalajara, Mexico, estimates that it would cost $960,000 to build a double main line, substations and branch lines for the transmission of electric power from Las Juntas, on the Santiago river near Guadalajara, to mines and mills in the Eazatlan and Tostotipaquillo districts. The cost of a single line is estimated at $650,000. The company asks that the mining concerns interested in the power project advance one-half of the estimated cost of the double line, or $480,000, the loan to be paid off with power and the money to draw eight per cent annually. The proposition has been taken under consideration by the mining men, and it is possible that a counter proposition will be made. The price asked by the Compañia de Tranvias for current is $120 a horse-power-year.

CHICAGO UNION TRACTION DECISION—The order recently entered by Judge Grosscup in the United States Circuit Court, directing the receivers of the Union Traction Company, which operates the street-car system on the north and west sides of the city, to turn these properties over to a new corporation called the Chicago Railways Company, for twenty years, has been reversed by the United States Court of Appeals. The decision of the higher court remands the case to the United States Circuit Court and leaves the traction situation where it was before the formation of the Chicago Railways Company. It was the opinion of the Court of Appeals that Judge Grosscup had no power to give possession to the Chicago Railways Company without the consent of the bondholders and stockholders of the underlying companies, and declared that the only manner in which the company can secure possession of the traction properties is through negotiations with the stockholders and the bondholders. The Chicago city council some time ago passed an ordinance granting to the Chicago Railways Company the right to operate the street-car systems on the north and west sides of the city. This ordinance, in the opinion of Justice Brewer, of the United States Supreme Court, who read the decision, was fair and should have been put in operation. The court held, however, that the wisdom of such a decision, or even public necessity from a business point of view, could not be taken into consideration, as the interests of the private property holders were the paramount points at issue. The action taken by the Court of Appeals hinged entirely on the question of jurisdiction. The power of Judge Grosscup to issue the order in favor of the Chicago Railways Company was the only thing assailed. The opinion of Judge Brewer praised the wisdom of the order issued by Judge Grosscup, but declared that legally it was wrong.

TELEPHONE AND TELEGRAPH.

NEW LONDON, WIS.—The farmers living south and west of the city are organizing a farmers' telephone company.

LADYSMITH, WIS.—The Chippewa Valley Telephone Company is about to make important changes, replacing the present system by a metallic circuit.

CHEHALIS, WASH.—B. E. Clement, who is closely associated with the Northwestern Long-Distance Telephone Company, has asked the city council of Chehalis for a twenty-five-year franchise. He promises to install an independent service here and have it in operation within ninety days if his request is granted.

NASHUA, N. H.—The work of installing an additional local switchboard is under way at the Factory street exchange of the New England Telephone and Telegraph Company. It is understood that the new board will contain six positions. It will be nearly as large as the one now in operation at the exchange. The new board is made necessary owing to a large increase in business.

EUREKA MILLS, VA.—At the annual stockholders' meeting of the Central Telephone Company, the following officers were elected: president, Captain A. J. Terry; secretary-treasurer, W. G. Williams; general manager, W. G. Williams; directors, J. C. Carrington, F. C. Thornton, S. A. Lawson and Lee W. Morton; executive committee, J. C. Carrington, T. C. Thornton and Captain N. L. Shaw.

CHESAW, WASH.—The Chesaw country is soon to be supplied with a telephone service, two independent lines now being under course of construction out of Chesaw. One is being built by local parties to connect with the railroad station four miles north, while the other is being built by ranchers living along the Kipling road, who recently organized under the name of the Farmers' Independent Rural Telephone Company. Poles are being set for both lines.

ATLANTA, GA.—The aldermanic board has agreed to grant a franchise to the Southern Bell Telephone Company for a period of thirty-three years. This provides for an annual tax of one per cent on the gross receipts of that company. Under the terms of this settlement the city will receive next year $4,000, or one per cent of the gross receipts of the company, which this year were $400,000. This is an increase of 300 per cent over the company's gross income six years ago.

COLUMBUS, OHIO—The United States Telephone Company's gross earnings for the first six months of this year amounted to $234,038, or $13,005 more than those for the first half of 1906, while its expenses involved $98,754, or $5,137 more than those for the first six months of 1906, leaving net earnings of $135,284, or $7,878 more than those for the first six months of last year. Charges, taxes and dividend disbursements on the company's preferred stock amounted to $82,048, or $4,851 more than the same items for the first half of 1906, leaving a surplus for the first half of this year amounting to $53,236, or $3,017 more than that for the first six months of last year.

MILWAUKEE, WIS.—President Alonzo Burt, of the Wisconsin Telephone Company, has made arrangements for the expenditure of about $1,500,000 in improving the entire system. The construction work will begin next spring when a new toll line to northern Wisconsin and the copper country will be built. This line will connect Iron Mountain on the Sioux road with Rhinelander, and other points will be given additional telephone service, including Tomahawk and Hurley. Many of the places which will be connected by the new line have never had telephone service. Between 200 and 300 miles of new territory will be covered, and over 600 miles of new wire will be strung.

ELECTRIC RAILWAYS.

DALLAS, TEX.—The city commissioners have decided not to forfeit the interurban franchise of Carter *et al.*, but to grant a six months' extension.

SACRAMENTO, CAL.—A party of surveyors employed by eastern persons are running lines for an electric railroad which will completely encircle Lake Tahoe and tap every important resort in both California and Nevada.

ATLANTA, GA.—At a meeting of the committee on roads and bridges of the board of county commissioners, the application of the Georgia Railway and Electric Company to run a line to Buckhead was granted by the committee.

TRAVERSE CITY, MICH.—The council has granted a sixty-year franchise to the Carter Construction Company, of Chicago, for a local street railway. It is proposed to build an interurban line north of Petroskey. Work will begin soon.

CARRIZO SPRINGS, TEX.—It is reported that D. J. Woodward, of San Antonio, who owns property near Cotulla, is behind a proposition to build an interurban line from Cotulla to Carrizo Springs, *via* his farm. He has subscribed $40,000 to start the project.

JOHNSTOWN, PA.—Final arrangements for the completion of the Southern Cambria Railroad's trolley line from this city to South Fork were effected when officials of the road contracted with the Tennis Brothers Company, of Pittsburg, for the electrical machinery.

MILWAUKEE, WIS.—The Milwaukee Western Electric Company, William Ross, president, has given a trust deed for $35,000 to the Citizens' Trust Company, and with the money raised will promote an electric line from Milwaukee to Pewaukee, Beaver Dam and other places.

SPRINGFIELD, ILL.—The stockholders of the Springfield & Southeastern Interurban Railroad have decided to issue bonds and to begin construction of the road between Springfield and Taylorville at once. President Finn, of the company, says work will begin in thirty days.

GREELEY, COL.—H. C. Havener, representing the Greeley & Denver Electric Railroad Company, reports success in securing the consent of property holders to a franchise for the proposed street-car line. The road will run southwest through Hillsboro and Johnstown to Denver.

WASHINGTON, D. C.—The annual meeting of the stockholders of the East Washington Heights Traction Railroad Company resulted in the reelection of the old board of directors and the following officers: O. C. Brothers, Jr., president; A. E. Randle, vice-president; C. B. Hillard, secretary, and C. B. Wiggins, treasurer.

SPRINGFIELD, ILL.—Two of the McKinley syndicate of interurban railroads have filed with the secretary of state certificates of increase of capital stock. They are the Danville & Eastern Illinois Railway Company, increased from $5,000 to $500,000, and the Springfield Belt Line Railway Company, increased from $5,000 to $500,000.

SAN ANGELO, TEX.—J. A. Williams, local representative of Colonel J. H. Ransome, who has been granted a franchise for a street-car system, states that it is the intention of the company to incorporate at once with a capital stock of $200,000. The officers of the company will be: J. H. Ransome, president; W. T. Noblett, San Angelo, vice-president; J. A. Williams, San Angelo, secretary and treasurer.

DES MOINES, IOWA—The street-car lines of the Des Moines City Railway Company within the city limits will be double tracked, beginning early in 1908. The work will cost more than $500,000 and may be completed within the year. There are about eighty miles of street railway in Des Moines at this time. Twenty or twenty-five miles have been double tracked. This does not include the side tracks.

SPRINGFIELD, ILL.—The Springfield branch of the Illinois Traction system is to be greatly improved by an increase in power. The contract has been let by the company for the installation in the Riverton power plant of a turbine generator, with a capacity of 9,500 horse-power. The plant is now capable of generating only 6,500 horse-power. The turbine will cost $80,000. A new substation has been installed at Buffalo, near this city.

WHEELING, W. VA.—Albert Schenk, who promoted the traction syndicate, organized to connect the Wheeling traction lines with a line to extend to meet the Columbus line, and to build to Pittsburg, making a through line from Columbus to Pittsburg, has bought the holding and franchises of the Mannington Light and Power Company, which will connect Clarksburg, Fairmont and Homewood. The line will be built to Moundsville and thence to Toronto, Ohio.

DECATUR, TEX.—M. J. Healy and Colonel L. J. Polk are planning to build the long-proposed East Line. They say the line is to be built from McKinney, Tex., to Mexico, but for the present they propose to make Decatur the western terminal. Colonel Polk resigned some years ago as vice-president and general manager of the Santa Fé system of Texas and has devoted himself to land exploitation and railway promotion.

PARSONS, KAN.—The city council has granted C. L. Brinser, representing a Harrisville, Pa., street railway company, a franchise for a street railway line which is to be part of an interurban system. There will be two lines, one extending north to Chanute and Pittsburg and the other south to Altamount and Edna and then on to Coffeyville. Mr. Brinser put up $25,000 as a deposit. Work is to begin in sixty days and the system is to be completed in one year.

ALBION, N. Y.—The power-house at Albion for the Buffalo, Lockport & Rochester Railway Company is nearly completed. It is built of cement blocks. The substations on the road will be at Gasport, Medina, Albion, Brockport and South Greece. A contract has been made with the Orleans Quarry Company for 40,000 cubic yards of crushed stone, to be used for ballasting the road between Brockport, Albion and Medina. It is expected now that cars will be running part of the distance in the fall.

YOUNGSTOWN, OHIO—The New Castle, Harmony & Butler street railway will have cars running between New Castle and Pittsburg by January 1. When the cars are running electric railway service will have been opened up all the way from Leavittsburg, Ohio, to Pittsburg. It is intended to extend the road on the west end from Leavittsburg to Garrettsville, a distance of about twelve miles, and then the plan of the promoters—a line from Pittsburg to Cleveland—will have been realized.

PITTSBURG, PA.—The Ashtabula Rapid Transit Company, which is owned by interests identified with the Pittsburg & Lake Erie Railroad and operates in Ashtabula, Ohio, has increased its capital from $150,000 to $500,000. This is preparatory to merging with the Pennsylvania & Ohio Traction Company, operating lines between Erie and Ashtabula, which will become a part of the through electric system that will parallel the Lake Shore Railroad from Buffalo to Cleveland, most of which is now constructed.

WALWORTH, WIS.—The sale of the Chicago, Harvard & Geneva Lake Electric Railway to the Elgin, Belvidere & Rockford Electric road interests has been consummated, and the latter will take immediate steps to not only close the gap between Harvard, the southern terminus of the Chicago, Harvard & Geneva line and its own line at Marengo, but will also build an extension of the line to Elkhorn, Wis., touching Delavan Lake at its eastern end. It is expected that both pieces of new road will be graded this fall and the entire line equipped for service early next spring.

DENVER, COL.—To finance the Denver Interurban's electric railroad, which has been in course of construction since the first of April and which will have forty-four miles of tracks, a mortgage for $1,250,000 has been filed in the county clerk's office. It was executed by A. D. Parker, of the Colorado & Southern Railroad, president of the company, and its secretary, W. A. Webb, in favor of the Guaranty Trust Company, of New York. The mortgage secures 1,250 $1,000 redeemable gold bonds bearing six per cent interest, payable July 1, 1937. The new road will be standard gauge and its route will be from Denver, by the way of Harris and Semper, Louisville Junction and Louisville, to and through Boulder, thence south and southeast to Marshall, Superior, and back to Louisville Junction. The line will also be built to Fort Collins. The Colorado & Southern Railroad is behind the new road and the Denver & Interurban, as one of its subsidiary enterprises, will add materially to the company's transportation lines in this state.

PERSONAL MENTION.

MR. W. T. CLARK, for the past seven years assistant mechanical superintendent of the General Electric Company, at Schenectady, N. Y., has resigned to become general superintendent of the Fairbanks-Morse Manufacturing Company, Beloit, Wis.

MR. G. E. EMMONS, general manager of the General Electric Company, Schenectady, N. Y., has been appointed by Governor Hughes a delegate to the trust conference of the National Civic Federation, to be held in Chicago, Ill., October 22.

MR. G. H. TRIPLETT, manager of the Temple (Tex.) exchange of the Bell County Independent Telephone Company for the past two years, has been transferred to the Houston office of the company and is succeeded by Guy Bryant, manager of the independent exchange at Nacogodoches.

MR. CLARENCE E. DELAFIELD, sales manager of the high-tension division of the Ohio Brass Company, Mansfield, Ohio, was in attendance at Montreal, Canada, at the annual convention of the Canadian Electrical Association, where he read a paper on "The History and Development of High-Tension Insulators."

MR. CLYDE N. COTTOM, of Jeannette, Pa., has been made superintendent of the West Penn Electric Company for the district comprising Connellsville, New Haven, Pa., and adjacent territory. He succeeds N. E. Shaw, who has been appointed superintendent of the Uniontown district. Curtis Moore becomes superintendent of the Jeannette office.

MR. FRANK C. MASON, former superintendent of police telegraph of Brooklyn, is now retired from active duties and is devoting himself to high-class farming near Utica, N. Y. Mr. Mason recently entertained a party of his New York friends to the best his well-cultivated farm affords, and that was sufficient to make every guest desire a return engagement.

MR. LUCIUS T. GIBBS, of New York, has been appointed electrical engineer of the Baltimore & Ohio Railroad, succeeding W. D. Young, who resigned. Mr. Gibbs was born in New York city in 1869. He was graduated at Cornell University in 1891 and made electrical engineer of the Milwaukee Street Railway Company. During the Spanish-American War Mr. Gibbs was assistant engineer on board the Newark.

MR. C. L. ROGERS, superintendent of the Uxbridge & Blackstone Street Railway Company, Uxbridge, Mass., has been made superintendent of the Worcester & Blackstone Valley Street Railway Company, Worcester, Mass., controlled by the New England Securities and Investment Company. He will take charge of the line as far as Millville, also operating that part of the Woonsocket, R. I., street railway from Millville to Woonsocket, which is leased from the Rhode Island company.

PROFESSOR HERSCHEL C. PARKER, of the department of physics, Columbia University, New York city, codiscoverer, with Walter G. Clark, of the Helion incandescent lamp, while hunting with Mr. Clark in Washington, in the Olympic Mountains was painfully injured by the accidental discharge of an automatic pistol which he was unloading. The bullet shattered his left hand, necessitating the amputation of one finger. Professor Parker has been confined to Grace Hospital, Port Angeles, Wash., for several weeks, but is recovering very rapidly now.

MR. JAMES L. RICHARDS, president of the subsidiary companies of the Massachusetts Gas Companies, has been elected president of the ten subsidiary companies of the Boston Suburban Electric Companies, succeeding Samuel L. Powers, who resigns to devote his time to law. Mr. Powers has been president of the Boston Suburban subsidiary companies but a short time, filling the vacancy caused by the resignation of A. D. Claflin, who resigned to devote his attention to the Claflin estate. Mr. Claflin, however, continues as president of the Boston Suburban Electric Companies, the holding company.

ELECTRICAL SECURITIES.

The most important change which took place in the market last week was the improvement in sentiment. This reestablishment of confidence is but a natural result of the stability with which industrials in general have withstood the onslaughts of the bear party for the last two months. The indications that the bond sale for the city of New York would prove a popular success also strengthened the bond market, and have given the sale of bonds an impetus all over the country. Again, this evidence on the part of investors of confidence in the ability of the leading American city to pay its financial obligations has created a more confident feeling abroad, and has brought about a disposition to accept business on other than a cash basis. This relieves the money market here, and the easing-up of rates has allowed many industries to secure the needed help to tide them over a difficult period. There is not much doubt as to a general easing-up in business. So strongly entrenched, however, is the business man in general that he has been able to put his house in order, and the retrenchment is awaited with composure and more or less satisfaction. There is hardly any doubt also that both cereals and textiles will command a higher price in the market for the fall and winter, which will mean the importing of large quantities of money to this country. Altogether, the situation is distinctly reassuring, and what was expected to be a disaster in the form of a business reaction will very likely prove a blessing in creating a let-up, so that business and business men alike may have some opportunity to recuperate from the strenuous period of the last three or four years.

ELECTRICAL SECURITIES FOR THE WEEK ENDING SEPTEMBER 7.

New York:	*Closing.*
Allis-Chalmers common	6⅝
Allis-Chalmers preferred	19½
Brooklyn Rapid Transit	48
Consolidated Gas	107
General Electric	129
Interborough-Metropolitan common	9¼
Interborough-Metropolitan preferred	26¼
Kings County Electric	110
Mackay Companies (Postal Telegraph and Cables) common	65⅛
Mackay Companies (Postal Telegraph and Cables) preferred	64
Manhattan Elevated	120
Metropolitan Street Railway	42
New York & New Jersey Telephone	100
Western Union	76½
Westinghouse Manufacturing Company	138

A dividend of $2 per share will be paid on October 15 to stockholders of the General Electric Company of record at the close of business hours on Saturday, September 14. The transfer books will not be closed.

Directors of the Interborough-Metropolitan Company have voted to pass the quarterly dividend of 1¼ per cent on the preferred stock. At the meeting of the New York City Railway directors, held September 6, the dividend on Metropolitan Street Railway stock was not considered.

Boston:	*Closing.*
American Telephone and Telegraph	106½
Edison Electric Illuminating	204
Massachusetts Electric	50
New England Telephone	108
Western Telephone and Telegraph preferred	—
Philadelphia:	*Closing.*
Electric Company of America	9
Electric Storage Battery common	45
Electric Storage Battery preferred	45
Philadelphia Electric	8
Philadelphia Rapid Transit	14⅞
United Gas Improvement	88¼
Chicago:	*Closing.*
Chicago Telephone	113
Chicago Edison Light	128
Metropolitan Elevated preferred	62
National Carbon common	67
National Carbon preferred	112

The annual meeting of the Allis-Chalmers Company, scheduled for September 6 in Jersey City, has been adjourned until September 26.

The annual meeting of the Chicago Edison Company will be held September 16, when the question of the new stock issue will come up. Books closed August 31 and reopen September 17.

The report of the Chicago Telephone Company for August shows 1,625 new telephones installed, of which 1,113 were in the city and 582 in the outlying districts of the company's territory. The total number in use August 31 was 194,091, of which 139,441 were in Chicago and 54,650 in the suburban towns. The total number in use January 1 was 170,834, making the gain in eight months 23,367 telephones.

The daily average of passengers on the South Side Elevated for August was 113,847, an increase of 25,308; for the Northwestern Elevated, 93,174, an increase of 19,998; for the Metropolitan, 136,517, an increase of 13,005.

ELECTRIC LIGHTING.

CARROLL, IOWA—George A. Long, of Grand Rapids, Mich., has bought the electric light plant and will put it in good condition.

DAVENPORT, IOWA—The Independent Power and Light Company will erect a power station of concrete blocks, 54 by 168 feet.

COLERAINE, MINN.—Frank McCormick has been granted the right to operate an electric light plant, which will be installed at once.

WILKES-BARRE, PA.—The Economy Light, Heat and Power Company has been absorbed by the Scranton Electric Light Company.

CONVERSE, IND.—Upon complaint of Fred Wilson, of Marion, the Converse Electric Company has been placed under control of L. O. Arnold, of this place, as receiver.

OXFORD, MD.—The Oxford Ice and Electric Light Company will erect at once an electric light and ice plant. The company has a contract with the town for fifty lights of 100 candle-power.

EUFAULA, ALA.—The Eufaula Gas, Electric Light and Power Company has disposed of its plant to a Philadelphia syndicate. E. Mandeville, of that city, will have personal supervision of the system.

NIAGARA FALLS, N. Y.—The second line for the transmission of power from this city to Syracuse has been completed and is now ready for use. The two lines are from five to fifteen miles apart.

BROWNSVILLE, TEX.—The city council has accepted the bid of Henry C. Ulen for the construction of a municipal system of electric lighting and waterworks. The bid was $65,940. Work will be begun at once and completed within twelve months.

SUPERIOR, WIS.—The municipal ownership of a lighting plant in Superior has been abandoned, the council having decided to make a contract with the local lighting company at a lower rate than formerly. The contract is for a year, with a clause which may lengthen it to five years.

SISSON, CAL.—The Southern Pacific Company has given out the information that it will build a large dam on the Klamath river and install an electric power plant, and that after the completion of the same the Southern Pacific Company would operate its trains over the Siskiyou Mountains by electricity.

ST. LOUIS, MO.—President O'Reilly, of the Board of Public Improvements, has completed blue prints showing the location of all the public arc and mantle lights in St. Louis, including 4,000 new ones to be installed. The total annual cost of lighting St. Louis will be about $860,000. The new lights will cost about $150,000. Down-town arc lights cost $98 a year.

TECUMSEH, NEB.—The Tecumseh city council has let the contracts for the machinery, wire, poles, etc., for the new electric lighting plant. The contract for the addition to the power-house, to accommodate the new machinery, was not let, but will be shortly. All old machinery will be discarded and a complete new plant, to cost $22,000, will be installed. J. E. Martz, of Seward, has been engaged as consulting and constructing engineer.

SODUS, N. Y.—At a meeting of the directors of the Sodus Gas and Electric Light Company, Dr. Albert E. Larkin, of Syracuse, was elected treasurer. The company is extending its line forty miles, lighting several villages. Arrangements have been made to close the power plant in this village, which has been in operation more than two years, the company having closed a deal with the Vanderbilt interests to furnish them power night and day. Dr. Larkin has become one of the principal stockholders.

TRENTON, N. J.—The Trenton chamber of commerce has taken up the old project to dam the Delaware river above the city for the purpose of supplying cheap light and power by electricity to the homes and business houses of this city. The Jersey legislature gave permission to dam the Delaware several years ago, but the Pennsylvania legislature has not acted favorably on the plan. An effort will be made to get a bill through the Pennsylvania legislature at the bi-annual session in 1908.

TOLEDO, OHIO—The committee on gas and light unanimously approved the ordinance granting to the People's Heating and Lighting Company the right to use the streets of the city. The ordinance as amended includes the entire city and provides that the East Side shall have a plant to cost not less than $100,000 and that a check for $30,000 shall be deposited with the city, to be forfeited in case less than $300,000 are expended at the end of two years. Public buildings must be heated at half-price whenever the company's lines run within 1,200 feet of them. The city has the right to regulate prices every five years. Provision is made against any merger and statements must be regularly filed with the city auditor.

SAN FRANCISCO, CAL.—The board of supervisors has awarded the contract for furnishing light to the municipality to the San Francisco Gas and Electric Company. The rates are as follows: each separate gas lamp per night, $0.087; for each separate arc light per night, $0.20713; for gas for public buildings per 1,000 cubic feet, $0.60; for electric current for public buildings and for power purposes, per kilowatt-hour, $0.04. The company is to light the streets with no less than 4,210 gas lamps and 1,616 electric arc lights or more. Of the arc lamps 1,366 shall burn all night and 250 may be extinguished at midnight, but only with the supervisors' consent. The total payments made to the company must not exceed the amount of the appropriation, $275,000.

PASADENA, CAL.—Engineer Ezra F. Scattergood's report on the improvements necessary at the municipal lighting plant recommends the installation of a plant of 1,250 kilowatts. For this purpose he suggests an appropriation of $195,000, and says that it will cost $50,000 more to put in an underground conduit system in the down-town district. Up to date the expenditure on the municipal lighting plant is $194,555, which includes sixty miles of distributing system, 310 arc lamps and 100 thirty-two-candle-power incandescent lamps, with a power-house equipment of one 200 and one 300-kilowatt generators. Superintendent Glass now desires that the city supplement this plant with another 500-kilowatt machine, a distributing system of about 1,500 kilowatts' capacity at a cost of $121,059, and an underground conduit system to cost $72,000, making in round numbers $193,000.

OBITUARY NOTE.

MR. W. J. PHELPS, vice-president of the Phelps Company, Detroit, Mich., died at Grace Hospital, Detroit, Mich., at half-past three, Tuesday afternoon, September 3. Mr. Phelps was one of the best-known lamp manufacturers in the country, and a wide circle of friends and acquaintances will join the bereaved family in mourning his demise. He was a man of peculiarly lovable disposition, made friends in every walk of life, and the genuine evidence of sterling character with which he always impressed even a casual acquaintance endeared him to those who had the opportunity of becoming well acquainted. William Joshua Phelps was born in Elmwood, Ill., November 19, 1866. He was a graduate of Knox College, Galesburg, Ill., and was a member of the Illinois Delta of Phi Delta Theta fraternity. He was an electrical engineer and inventor. The best-known and most useful of his inventions was the "Hylo" lamp, which he manufactured in its various forms. Mr. Phelps is credited with being the originator of the turn-down lamp art, which is proving to be an extensive business. He was also the inventor of the motorless flasher, which has proved to be of great use in the electrical advertising field. He was a member of the American Institute of Electrical Engineers, the American Society for the Advancement of Science, the Illuminating Engineering Society and the Detroit Engineering Society. He is survived by a widow and two children, his father, mother, and a brother and sister. Mr. Phelps had undergone a radical mastoid operation at Grace Hospital several weeks ago, and was in a fair way to recover. On August 31 he complained of severe pains in his head, and during the morning fell into a coma, from which he never aroused. The cause of death appears to have been inflammation of the membranes surrounding the brain. The interment was made on Friday, September 6, in Springdale Cemetery, Peoria, Ill.

LEGAL NOTE.

FUNCTIONS OF A PUBLIC OFFICIAL WITH REGARD TO STREET RAILWAY LIABILITY—A street commissioner who has refused to permit the tearing up of a street for the purpose of removing the rails of a street-railway system therefrom, actuated merely by the hope that someone will operate the road, without considering the only questions within his power, as to the interference of the tearing up of the street with public travel and its effect upon the pavement, is held, in French *v.* Jones (Mass.), to be properly compelled by mandamus to hear and determine such questions.

INDUSTRIAL ITEMS.

THE ECONOMICAL ELECTRIC LAMP COMPANY, 96 Warren street, New York city, is distributing some interesting literature devoted to the sales of the Economical turn-down lamp.

THE WATSON-STILLMAN COMPANY, New York city, in catalogue No. 71 describes and illustrates its hydraulic pumps and accessories. The company's product includes an extensive line of motor-driven pumps, both direct-geared and belted.

THE WIRE AND TELEPHONE COMPANY OF AMERICA, Rome, N. Y., is distributing a new booklet devoted to its "Easophones." The "Easophone" is a very successful hand telephone which is being rapidly adopted for all kinds of installations.

THE BROOKFIELD GLASS COMPANY, New York city, has published a catalogue devoted to standard Brookfield screw glass insulators and knobs for all purposes. The book is handsomely illustrated, gives full dimensions, the barrel quantity, and also the approximate shipping weight per 1,000 pieces.

I. P. FRINK, 551 Pearl street, New York city, the manufacturer of the well-known Frink reflector, is securing a number of large contracts for reflector systems in all parts of the country. During the past week orders were taken for a mile of reflectors in one day.

THE TRUMBULL ELECTRIC MANUFACTURING COMPANY, Plainville, Ct., in its September issue of "Trumbull Cheer" draws attention to the New Code porcelain-base "B" switches, and the fibre-base and porcelain-base battery switches. This little bulletin is well worth securing, and buyers interested in switch supplies should be on the Trumbull company's mailing list.

THE GERMANIA ELECTRIC LAMP COMPANY, Harrison, N. J., has published a new price list and catalogue containing a great deal of information of interest to lamp users. In addition to the prices listed there are full descriptions of the new types of reflector lamps, which are a specialty of the Germania Electric Lamp Company. This price list will be sent to any one interested upon request.

THE ADVERTISING MIRRORGRAPH COMPANY, Brooklyn, N. Y., has published a leaflet devoted to its "Thermo-Blink" No. 6. This is a device particularly adapted for signal lights. With the apparatus, one lamp is held in reserve, while the other burns. Should the lamp that is burning give out, the reserve lamp is automatically thrown in the circuit. Information concerning this device will be furnished upon request.

THE COOPER HEWITT ELECTRIC COMPANY, 220 West Twenty-ninth street, New York city, has published a list of typical installations of Cooper Hewitt lamps. When one realizes the comparatively recent development of the mercury vapor lamp, it is astonishing to discover the variety of purposes for which it is being used. In each case there is given the name of the company and the number and type of lamps employed.

FAHN & McJUNKIN, 201 East Sixteenth street, New York city, will design and build the equipment for the Linolite Company of America. The company will not manufacture the lighting units, as stated in the issue of the ELECTRICAL REVIEW for August 24. In the same note mention was made of the Carpenter pump interests, which Fahn & McJunkin had purchased. These are not used for exhausting lamps, but are the secondary vacuum pumps known generally as the Packard pumps.

THE DALE COMPANY, New York city, has recently finished a handsome piece of work for the Waldorf-Astoria Hotel, New York city. This includes the gold-plating of the columns and railing running about the main desk in the foyer of the hotel. These columns are about a foot wide and three inches thick, and used to be of bronze. They have now been plated with three coats of gold, and will support a railing of the same character. It is stated that the gilding cost about $5,000.

THE CUTTER COMPANY, Nineteenth and Hamilton streets, Philadelphia, Pa., has published a handsome booklet entitled "Save Time, Money and Trouble." This is devoted to illustrations and descriptions of "I-T-E" circuit-breakers. The booklet is compact in form, the information is complete, and the illustrations are splendidly worked up. Altogether it is an exceptional piece of advertising, and well worth going to some trouble to secure. Copies will be sent upon application to the company.

THE DOUBLEDAY-HILL ELECTRIC COMPANY, Pittsburg, Pa., has ready for distribution its new catalogue comprising 725 pages, ten inches by six and one-half inches, giving a complete, comprehensive and up-to-date listing of electrical material. The obsolete matter has been entirely eliminated, and nothing but the latest and most approved material will be found listed. Apparatus covering systems of from 100 to 5,000 volts are illustrated. Tantalum lamps, and, in fact, all the new higher-efficiency devices, are shown.

THE BOSSERT ELECTRIC CONSTRUCTION COMPANY, Utica, N. Y., announces that it has disposed of the switchboard and panel-board department of its business to the Nyelec Switchboard Company, Twenty-eighth street and First avenue, New York city, which has the sole right to manufacture Bossert type switches and panel-boards. The former superintendent of this department at the Bossert factory will be in charge of the new factory. The company will be represented by the R. B. Corey Company, 39-41 Cortlandt street, New York city, as sales agent.

THE DIELECTRIC COMPANY OF AMERICA, Belleville, N. J., has just issued a new catalogue on its weatherproof wires. The catalogues are bound in Russia leather with round corners for pocket service. Besides containing tables giving the weights of the various sizes of wire and other useful information, there is included a lot of blank sheets suitable for memoranda. This company is also putting through the press a descriptive catalogue on its underground transmission system. This system is constructed without the use of conduits or lead cables. By the use of this method it is possible to carry telephone and telegraph wires in the same ducts with high-tension lines. Either of these catalogues will be mailed to any one interested on request.

THE STANDARD UNDERGROUND CABLE COMPANY, Pittsburg, Pa., which has for the past year maintained Pacific Coast headquarters in Oakland instead of San Francisco, has now permanently located at 511 to 514 Shreve Building, San Francisco, Cal. A. B. Saurman continues as Pacific Coast manager. The new Oakland factory is four times as large as the old factory which was destroyed by fire shortly after the earthquake last year. It is as nearly fireproof as is physically possible, is equipped with the most modern machinery for the manufacture, on short notice, of insulated wires and cables for practically any service. It is also equipped with complete warehouse facilities for handling the products of its Eastern factories carried in stock for coast delivery.

THE W. J. BARR ELECTRIC MANUFACTURING COMPANY, Cleveland, Ohio, will be pleased to send its new catalogue illustrating and describing an extensive line of electric heating and cooking devices. Notable among the devices listed is the new plug switch domestic iron, which introduces the company's latest departure in effecting connection between the flexible lead and the flat-iron. Another device which has attracted considerable attention is the cast-aluminum soldering pot. This is made without a water jacket, as the apparatus is so designed that the temperature attained is under positive control and there is no danger of the glue being burned by excessive heat. This catalogue may be secured from the main office at Cleveland, or from A. F. Brown, the eastern sales manager, 120 Liberty street, New York city.

DATES AHEAD.

Jamestown Tercentennial Exposition. Norfolk, Va., April 26 to November 30.

Canadian Electrical Exhibition. Montreal, Quebec, September 2-14.

Old Time Telegraphers' and Historical Association and Society of the United States Military Telegraph Corps. Annual meeting, postponed until next year.

Vermont Electrical Association. St. Albans, Vt., September 18-19.

Colorado Light, Power and Railway Association. Annual convention, Denver, Col., September 18-20.

Street Railway Association of the State of New York. Annual meeting, Kingston, N. Y., September 21.

New York State Independent Telephone Association. Annual convention, Syracuse, N. Y., September 25.

Railway Signal Association. Annual meeting, Milwaukee, Wis., October 8-10.

American Electrochemical Society. Fall meeting, New York city, October 10-12.

American Street and Interurban Railway Association. Annual meeting Atlantic City, N. J., October 14-18.

Record of Electrical Patents.

Week of September 3.

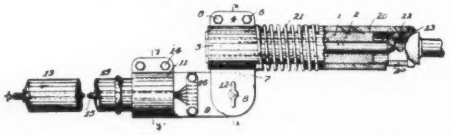
864,781. UNIVERSAL OUTLET OR JUNCTION BOX. John L. Gleason, Boston, Mass. An outlet box with openings in its sides and ends.

864,798. PORTABLE HOIST. James L. Pilling, Chicago, Ill. A motor-driven hoist.

864,840. APPARATUS FOR ELECTRICALLY REMOVING AND SEVERING METAL. Royal E. Frickey, Berkeley, Cal. A device for the use of the electric arc for cutting metal.

864,842. ELECTRIC DRIVE FOR PAPER-MAKING AND LIKE MACHINES. James R. Happer, Linwood, Scotland, assignor of one-half to James Bertram & Son, Limited, Edinburgh, Scotland. A variable voltage is obtained by opposing the voltage of a motor-driven generator to that of the line.

864,858. AUTOMATIC CIRCUIT-CLOSER. Hermann G. Pape, New York, N. Y. A telephone receiver switch.



864,840.—Apparatus for Electrically Removing and Severing Metal.

864,866. AUTOMATIC TRAIN-STOP. Hiram G. Sedgwick, Mill Valley, Cal. A magnetically controlled brake.

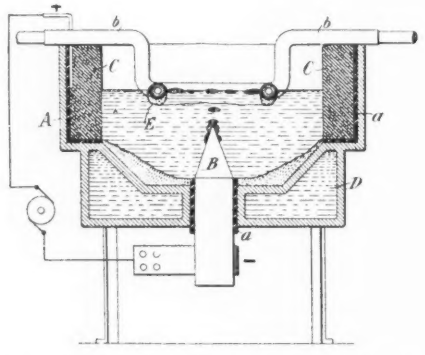
864,887. SUPERVISORY SYSTEM FOR TELEPHONE LINES. William W. Dean, Chicago, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill. A supervisory signal is actuated by a relay in the cord circuit.

864,899. STEP SWITCH. Christian Krämer, Frankfort-on-the-Main, Germany, assignor to Felten & Guilleaume-Lahmeyerwerke Actien-Gesellschaft, Frankfort-on-the-Main, Germany. An eccentrically mounted contact lever produces step by step motion.

864,909. SOUND-PRODUCING DEVICE. John P. Northey, Toronto, Ontario, Canada. A whistling device operated by an electrical magnet.

864,912. JOINTED TROLLEY POLE. Harry Padley, Elyria, Ohio. The pole is hinged substantially at its middle.

864,915. ELEVATOR SIGNALING APPARATUS. Charles A. Reinerz, Hoboken, N. J., assignor to Elevator Supply and Repair Company. An intercommunicating signaling system for elevators.



864,928.—Electrolytic Production of Earth-Alkali Metals.

864,928. ELECTROLYTIC PRODUCTION OF EARTH-ALKALI METALS. George O. Seward and Franz von Kügelgen, Holcombs Rock, Va., assignors to Virginia Laboratory Company, New York, N. Y. The current density at the surface of the submerged cathode is so high that metal is formed in a molten state.

864,947. CLAMP FOR ELECTRIC WIRES. Elisha W. Buffington, Fall River, Mass., assignor of one-half to Marietta M. Huggett, Fall River, Mass. A split insulating knob.

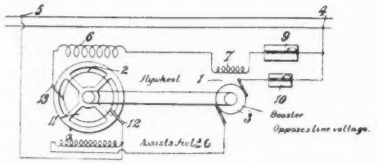
864,950. TELEGRAPH TRANSMITTER. Josiah A. Carter, Jr., Atlanta, Ga. A combined key-lever and vibrator.

864,957. PORTABLE SEARCH-LIGHT. John Dickens, Passaic, N. J., assignor, by direct and mesne assignments, to the Standard Sheet Metal Company. A portable electric battery lamp.

864,961. AUTOMATIC ELECTRIC GONG-RINGING DEVICE FOR STREET CARS. Nathan Fallek and George F. Wolfe, Denver, Col., assignors to the Standard Electro-Automatic Signal Device Company, Denver, Col. The gong is controlled by the controller handle.

864,965. TROLLEY HEAD. James D. Gibbs, Louisville, Ky. Automatic wire-guards are provided.

864,971. ELECTRIC SIGNALING DEVICE. Alfred Larsson, Buffalo, N. Y. An electromagnetic sounder.



865,011.—Connection System for Direct-Current Electric Motors.

864,990. WATER GOVERNOR. Walter J. Richards and Charles P. Tolman, Milwaukee, Wis. An electrically operated governor.

864,995. JUNCTION-BOX-COVER ROSETTE. Frank J. Russell, New York, N. Y. A rosette with a locking base connection.

865,011. CONNECTION SYSTEM FOR DIRECT-CURRENT ELECTRIC MOTORS. Raoul Brun, Havre, France. The speed of the motor is controlled by opposing the variable generator potential to that of the line.

865,013. RAILWAY BLOCK-SIGNAL SYSTEM. Winthrop M. Chapman, Needham, Mass. An electrically operated system.

865,016. ELECTRIC FURNACE. Walter G. Clark, New York, N. Y., assignor to Electric Furnace Company, Portland, Me. A resistance furnace.

865,038. WATER-TIGHT ELECTRIC BELL. Walter C. Hill, London, England. The striking mechanism is enclosed in a water-tight cylinder.

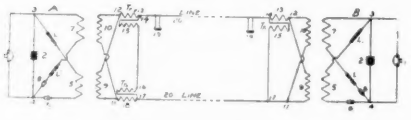
865,059. MEANS FOR ATTACHING PIGTAILS TO CARBON BRUSHES. Maxwell W. Robertson, New York, N. Y. The pigtail is held against the brush by clamps.

865,068. ELECTRIC GENERATOR. Klas Weman and Alfred Larsson, Buffalo, N. Y. A magneto-machine.

865,083. LUBRICATING MECHANISM. Niels A. Christensen, Milwaukee, Wis. A self-lubricating bearing.

865,093. CURRENT TRANSFORMER. Oswaldo de Faria, Paris, France. An electrolytic transformer.

865,108. PRINTING TELEGRAPHY. Isidor Kitsee, Philadelphia, Pa. A means of controlling the paper feed of printing telegraphs.



865,215.—Art of Telephony.

865,215. ART OF TELEPHONY. Daniel M. Therrell, Charleston, S. C. Transformers attuned to the essential voice frequencies are used.

865,219. END CONNECTION FOR CONDUCTORS ON FIELD-MAGNETS OF ALTERNATE-CURRENT GENERATORS. Miles Walker, Hale, Altrincham, England, assignor to Westinghouse Electric and Manufacturing Company. The end conductors have laterally projecting lugs engaging with similar lugs on the core.

865,291. LIGHTNING ARRESTER. William J. Bell, Deerfield, Wis., assignor of one-third to Howell B. Fargo, Deerfield, Wis. A spark-gap arrester.

865,323. TROLLEY. Leslie S. Wilder, Northampton, Mass., assignor of one-half to Henry S. Wilder, Easthampton, Mass. A wheel with automatic wire-guards.